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*JOBLESS GROWTH: APPROPRIABILITY,
FACTOR-SUBSTITUTION, AND UNEMPLOYMENT*

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Abstract

A central determinant of the political economy of capital-labor relations is the appropriability of specific quasi-rents. This paper is concerned with the general-equilibrium interaction of appropriability and characteristics of technology — namely, the embodiment of technology in capital and capital-labor substitutability in the technological menu. Technological embodiment means that the supply of capital is effectively much less elastic in the short than in the long run, and is therefore more exposed to appropriability; technology choice implies that an attempt at appropriating capital will induce a substitution away from labor in the long run, and constitutes a mechanism to thwart appropriation. Shifts in European labor relations in the last three decades offer a good laboratory to explore the empirical relevance of those mechanisms. The evolution of the labor share, the profit rate, the capital/output ratio, and unemployment — which we examine more particularly in the case of France — appears highly supportive.

1. Introduction

The political economy of capital-labor relations is driven by multi-faceted approaches to the creation and appropriation of specific quasi-rents, that arise whenever those factors come together in production. Rent appropriation affects interactions in settings as diverse as the determination of wages in the presence of relationship-specific investments, the organization of labor unions, or the politics of labor market regulation. Although pre-contracting can, in principle, help compensate each factor according to its ex-ante terms of trade when it must make relationship-specific investments, the degree to which it can play this role in practice is limited by the complexity of the required contracts and by political attempts at preventing such outcomes through the regulatory environment.

The appropriating factor can expect to increase its share of value-added in partial equilibrium, but the very attempt at appropriation reduces the incentive for the other factor to invest.

The general-equilibrium consequences of this fact include the underemployment and market-segmentation ("involuntary unemployment") of the appropriating factor, as well as a number of other central macroeconomic features discussed in previous work (Caballero and Hammour 1996a, b, c).

The general-equilibrium outcome of appropriability depends crucially on the two factors' supply elasticities, and on the degree to which they need each other in production. This observation brings to the fore two basic characteristics of technology, that are the principal focus of this paper: the embodiment of technology in capital; and capital-labor substitutability in the available technological menu. Technological embodiment means that capital is effectively much less elastic in the short than in the long run, and is therefore more exposed to appropriation. Substitutability implies that an attempt at appropriating capital will induce a substitution of capital for labor in the long run, an additional instrument to thwart appropriation.

This paper explores observable aspects of the dynamic mechanism that governs the interplay of appropriability and the above-mentioned technological features, which allow us to trace over time the general-equilibrium implications of appropriability and, in particular, its technological dimension. Appropriation operates at various levels of interaction between capital and labor, that range from individual transactions up to the political economy of labor-market regulation. Our empirical focus is on the higher, political levels of interaction, because they are easier to identify and track over time. The European experience over the last three decades offers a good laboratory. European economies experienced a substantial institutional buildup in favor of labor, which provides us with a clear case of increased capital appropriability and allows us to examine its macroeconomic consequences at different frequencies.

The deep transformations experienced by European capital-labor relations during the last three decades are well documented.[1] The 1950s and 60s saw the development of basic institutions that were to become a platform for political intervention in capital-labor relations. This period culminated in the intensification of the labor movement and the wage pressures of the late sixties and early seventies — May 68 in France, the Hot Italian Autumn of 69, etc. Those developments, while arguably warranted as a way for labor to share more evenly in the rapid European expansion since the end of the war, had the misfortune to clash head-on with the oil shocks of the 1970s. From a pure efficiency point of view, an appropriate response to the depressed conditions of the 1970s would have been an institutional shift and wage adjustments in favor of capital. The actual outcome, on the contrary, was characterized by a sustained political momentum for further institutional gains by labor. Faced with deteriorating aggregate conditions, insider labor attempted to build fences around itself through a combination of job-protection regulations and political resistance to large-scale industrial labor shedding, increases in unemployment and early-retirement compensation, and hikes in social charges on payrolls.[2]

With the above-mentioned developments in capital-labor relations came the well-known buildup in unemployment, from levels below 3 percent during the 1960s to levels above 10 percent today. The rise in European unemployment was slow during the first half of the 1970s

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[1] A chronology of labor-market developments in the case of France can be found in appendix 6.1. The analysis summarized in this paragraph is developed in Caballero and Hammour (1996c).

[2] Lazear (1990), for example, estimates that severance payments and advance notification for job termination rose by an average of 60 percent in OECD countries from the late 1960s to the late 70s, and greatly exceeded that rate in most large European economies.

and only gradually reached current levels, with a short pause during the expansion of the late 1980s. During the 1970s, the trade-off did not seem unfavorable to labor: unemployment increased, but so did wages and the labor share. Moreover, the protective measures taken appear to have softened the impact of aggregate shocks on employment. Analysts of that period saw in the widening "wage gap," apparent in the growth of wages and of the labor share, evidence that points to unemployment of the Classical type (e.g., Sachs 1979; Bruno and Sachs 1985).[3]

While unemployment kept rising in the 1980s, wage growth slowed below productivity, the labor share plummeted, and the deal turned sour for labor.[4] Unemployment had turned non-Classical. The OECD (1986) study on labor-market flexibility, for example, while it agrees with the view that a wage gap was responsible for high unemployment in the 1970s, pointed out that this gap had been declining while unemployment kept rising. Moreover, what appears as a virtual "depression" from the point of view of employment, appears much less so from the point of view of capital. Although they never resumed the "catching-up" growth rates of the 1950s and 60s, capital and output exhibited sustained growth — especially once one controls for the productivity slowdown and for the high interest rates of the 1980s and early 90s. Capital and labor in Europe seem to have parted company, with capital growing at sustained rates and yielding returns comparable to the 1960s, while labor seems to be following a much gloomier path.

The European economies' rich dynamic response, we argue in this paper, is consistent with the interaction of appropriation and technology at different frequencies. Put succinctly, the joint increase in unemployment and in the labor share during the 1970s is consistent with the short-run response of existing capital that faces an appropriation push. Given the irreversibility of investment and technology choice, the response of capital in place is highly inelastic — with very limited possibilities to withdraw or substitute labor away. Increased appropriation can therefore be effective in the short run, and shift part of the quasi-rents in favor of labor. Over the longer run, however, capital is much more flexible. In response to an appropriation attempt, it will select and develop technologies that are much less labor intensive, and will reach an equilibrium investment level that will guarantee it returns equivalent to what it can get elsewhere in the world. The first factor indicates that capital investment may continue at a sustained rate, despite further increases in unemployment; and the second that it will recover its profitability, at the expense of the gains made by labor in the short run. This implies a rise in the capital/labor ratio and a recovery in the capital share — which has not only recovered in Europe, but clearly overshot its initial level.

In fact, there is clear evidence of a correlation between capital-labor substitution and indicators of appropriability. Figure 1.1 plots, for the OECD countries, the change in the capital/labor ratio between 1970 and 1990 against an index of job protection (the sum of maximum mandatory severance payments, in months of wages, and of the advance notification period, also in months).[5] The only point clearly off the positive relationship corresponds to Japan, in the lower

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[3] See also Krugman (1985) and Kouri, de Macedo and Viscio (1985) for the specific case of France, which we study more particularly in this paper. Both papers take the wage gap as given, and explain the slow buildup of unemployment as due to adjustment/firing costs (Krugman) and putty-clay dynamics (Kouri et al.).

[4] Blanchard (1997) documents the large decline of the labor share during the 1980s and 1990s for France, Italy and Germany; this decline was not observed in countries with more "flexible" labor markets, like the US or the UK.

[5] This figure was kindly given to us by David Coe. It goes without saying that this index of job protection

Figure 1.1: Capital-Labor Substitution and Job Protection

Job Protection (months)

K/L-growth (%): 1970-90
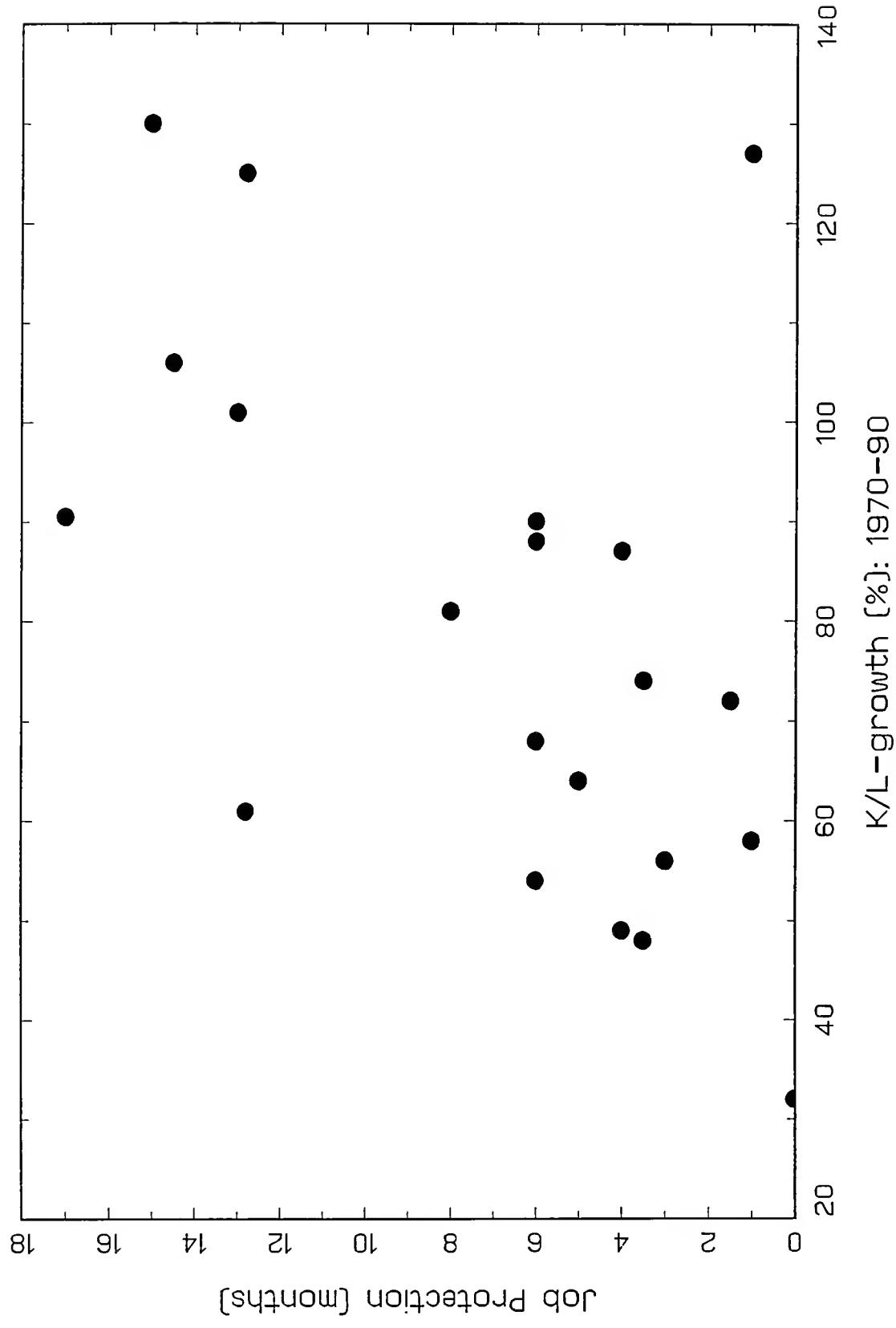
right corner.

It is important to highlight the fact that the marked differences in the economy's short- and long-run response to an appropriation push, as analyzed in this paper, are not driven by a reversal in the shock itself. The common presumption that European labor markets have regained substantial flexibility in the 1980s is based on the observation that wages have grown slower than productivity — in addition to clear specific cases where extensive reforms have been implemented (e.g., in the UK). However, even in the absence of any institutional reversal, the observed decline in wage growth and in the labor share are a natural outcome of the general-equilibrium mechanisms outlined above. Paradoxically, once dynamics have worked their way, detrended wages may even fall *below* their level prior to the appropriation push, even as capital-labor substitution takes place. The reason, we argue, is that appropriability causes inefficiency in factor allocation; and, in the long run, the resulting fall in productivity will mostly be borne by inelastic labor.

Our argument concerning the interaction of appropriability and technology is quite general, and can also be applied to *demand* factors that determine the menu of opportunities available to capital. We speculate on such broader implications in the concluding part of this paper. In economies with heavily regulated labor markets, the current process of globalization has effects similar to an increase in the technological substitutability of capital and labor, as it offers further chances for capital to specialize and exclude labor. Although globalization can improve productivity, investment, and growth, it may not benefit employment and may possibly reduce the earnings of workers. The recent experience of Argentina is a case in point. Its European-style labor-market institutions, whose consequences have long been contained through various dimensions of government intervention, have turned more problematic following recent privatization and trade liberalization. The economy seems to be experiencing a sharp process of post-reform capital deepening and growth without jobs.

The rest of this paper is divided into four sections. Section 2 describes the specific case of France in more detail, as representative of the European experience. Section 3 outlines a dynamic model of the interactions of appropriation and technology choice that we use in section 4 to develop our basic propositions. To interpret the European experience, we calibrate the model based on French data and examine its ability to track the dynamics of basic macroeconomic variables — unemployment, the capital/output ratio, the labor share, the profit rate, etc. — based on the major institutional and aggregate shocks experienced by the French economy. Section 5 concludes.

2. The Experience of France

In order to analyze the European experience, we choose France as a prototypical case. Many of the phenomena that characterize French macroeconomic performance find a counterpart in the other Western European economies, although often with important differences in timing and magnitude.

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is far from a sufficient statistic for the actual severity of — written and unwritten — firing restrictions. Data sources: Maximum notification period and severance pay, OECD(1993), table 3.8, p. 97; capital/labor ratio, OECD Business Sector Data Base, 1996/2.

2.1. French Macroeconomic Performance: 1967 to the Present

Figure 2.1 presents the time-path over the 1967-95 period of a number of French macroeconomic variables that play a central role in our argument.[6] In the top two panels, we chose the unemployment rate and the capital/output ratio to characterize the fortunes of labor and capital during this period. Having remained for years below 2 percent until around 1967, unemployment climbed to 3 percent in 1968 and hovered around that level until 1974. It is at that point that it began rising sharply and uninterruptedly for more than a decade, a surge that was only interrupted temporarily by the economic expansion of the late 1980s. What appears as a depression from the perspective of employment, looks much less so from the point of view of capital — which grew at a generally sustained rate despite the high real interest rates that prevailed in France in the 1980s and early 1990s (see panel f). A marked substitution phenomenon seems to dominate this period, taking the capital/output ratio in the business sector from around 2.5 in the early 1970s to around 2.8 in the early 1990s. In comparison, the same ratio in the US has remained essentially flat during this period.[7] We return to the measurement of substitution in sub-section 2.3.

Panels (c) and (d) document the evolution of wages and profits. The period can be divided into three phases. The first phase, which ends around 1974, is characterized by fast growth in wages and healthy profit rates. It appears as a continuation of the expansionary 1950s and 1960s, but with worker compensation making more rapid progress. A break occurs in 1974, starting a phase that lasts until the early 1980s, where wages continue growing at a brisk rate while the profit rate plummets. Wage progression is all the more striking considering the oil shocks of the 1970s, and seems to take place at the expense of existing capital. This is a strong indication of progress in labor's position in the sharing of quasi-rents. The last phase is characterized by a significant slowdown in wage progression coupled with a strong recovery in profits. The effect of appropriability on the profitability of capital does not seem to persist in the longer term.[8] Another way to characterize those three phases is to look at the share of value-added that goes to each factor, as depicted in panel (e). The labor share is around 0.67 in the first phase, peaks at about 0.72 in the second phase, then experiences a sharp decline down to 0.62 in the third phase.

Our period of study is characterized by a number of major aggregate shocks. After the three decades of brisk economic growth that followed the war, France experienced, like other countries, the two oil shocks of the 1970s, followed by general monetary and fiscal restraint throughout the

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[6]Notes for figure 2.1: *(i)* Unemployment and the labor force correspond to the civilian population. *(ii)* All other variables are for the business sector of the economy. *(iii)* Product wages are measured as compensation per employee divided by the GDP deflator. *(iv)* The profit rate is measured as the ratio of the current operating surplus, over the current stock of capital times the investment deflator. *(v)* The labor share is measured by the ratio of employee compensation over value added.

[7]This pattern is particularly pronounced in manufacturing. Looking at the capital/labor ratio over the period 1970-1990, we find that it increased by 122 percent in French manufacturing, versus 88 percent in the US. Normalized by the capital/labor ratio in the trade sector, the increase was 25 percent in France versus 8 percent in the US.

[8]The contrast in real wage growth between the 1970s and 1980s is all the more striking if we look at compensation per hour rather than per employee. From the late 1960s to the late 1970s, average weekly hours per employee fell gradually from around 45 to 40; they dipped to 39 following the official one-hour work-week reduction of 1981; and have remained at that level since. Moreover, a fourth week of paid vacation was introduced in 1969; and a fifth week in 1981.

Figure 2.1 : France (1967 - 95)

(a): Unemployment
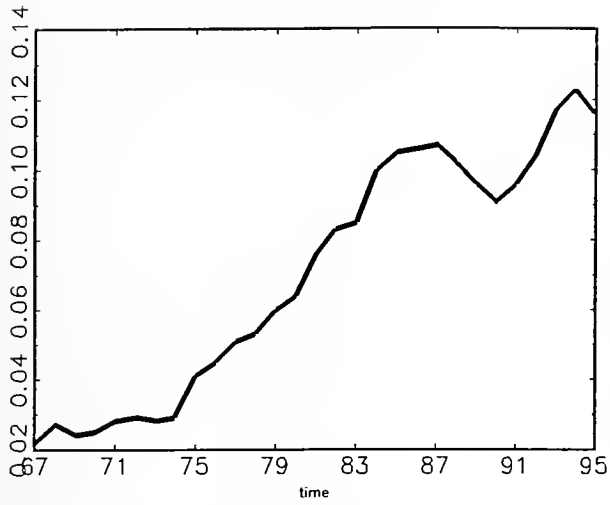
(b): Capital/Output Ratio
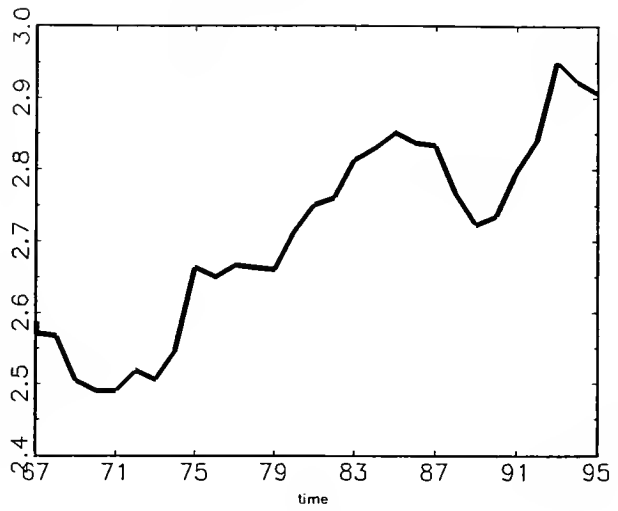
(c): Log. of Product Wages

(d): Profit Rate

(e): Labor share

(f): Real Interest Rates

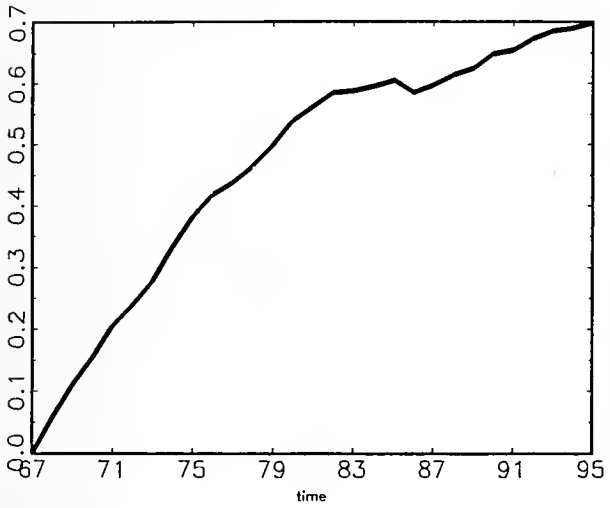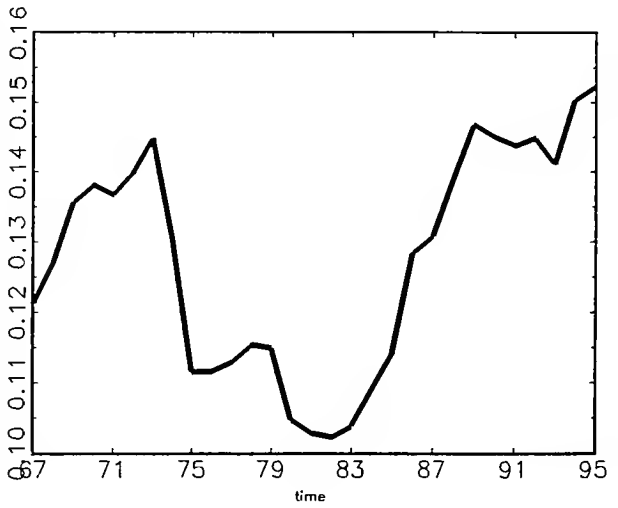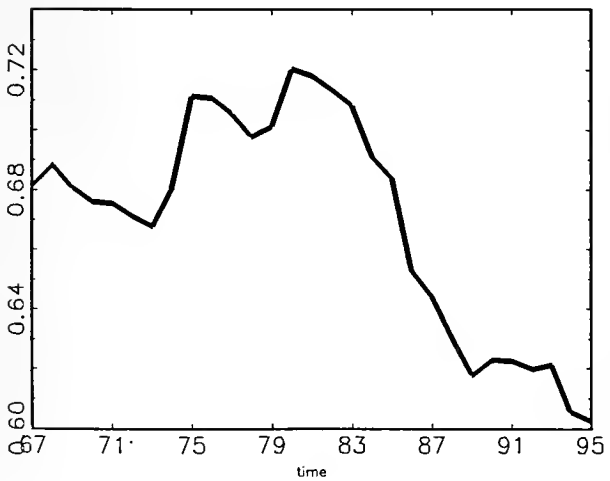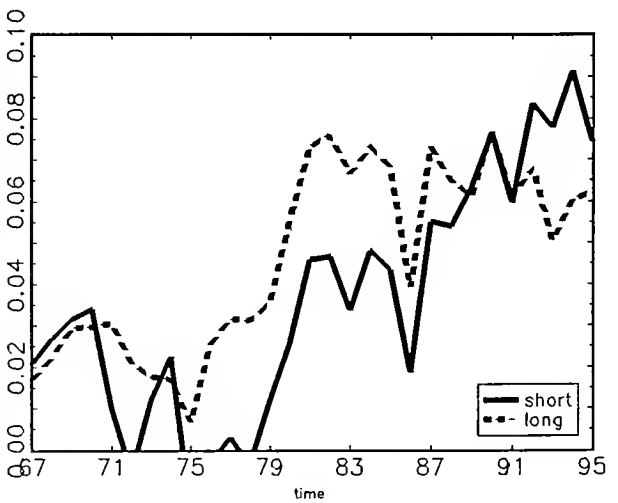rest of the period. Panel (f) of figure 2.1 depicts the path of real interest rates. Both short and long rates were very low in the inflationary 1970s, and very high following the monetary tightening of the early 1980s — peaking near the end of the period during a phase of currency turbulence and determined policy to defend the Franc.[9]

2.2. The Evolution of Capital-Labor Relations

A detailed chronology of post-war institutional developments in French capital-labor relations is given in appendix 6.1. In essence, one can break the post-war period into five phases. Phase I covers the period 1945-1968, characterized by rapid economic growth and labor shortages — which necessitated a steady flow of immigrant labor. That period saw the creation of a number of institutions that were to become the basis for political intervention in capital-labor relations: the generalized social security system; the unemployment insurance system (UNEDIC, and the ANPE employment agency); the minimum wage (the SMIG, later to become the SMIC); new representative bodies for centralized bargaining (the CNPF for firms; and the CGT-FO and CFDT labor unions).

The institutional push in favor of labor, whose consequences we analyze in this paper, unfolded during phases II to IV. Phase II starts with the student revolts and general strike of May 1968 and ends with the first oil shock of 1973. It is characterized by rapid wage growth and institutional gains by labor, as epitomized by the Grenelle accords of May 27, 1968. Given that wage growth had been slower than productivity, this phase can be seen as a step toward a more even participation of labor in the fruits of economic growth. Phase III starts with the first oil shock of 1973 and ends with the coming to power of the left in 1981. It is characterized by a sustained political momentum for institutional gains by labor in an environment of depressed aggregate conditions. Given the rise in unemployment, the political focus turned to the protection of existing jobs: the 1975 introduction of an administrative authorization for economically-motivated dismissals; more protective unemployment benefits; and early-retirement compensation (whose effect on wage determination is similar to unemployment benefits). Phase IV starts with the 1981 election of François Mitterand and his socialist-communist coalition until the socialists' defeat in the legislative elections of 1986. The new government introduced an array of "pro-labor" measures: a rapid increase in the minimum wage; a reduction in the work-week and the adoption of a fifth week of paid vacation; restrictions on determined-duration and temporary work contracts; the Auroux labor laws of 1982; and a nationalization program for banks and major industrial groups.[10]

Finally, phase V covers the period from the return of right-wing parties to power in 1986 until the present. Although consecutive governments did introduce limited reforms (including

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[9] Real interest rates were constructed by subtracting expected inflation (in the GDP-deflator) from the average inter-bank money rate (the "short" rate) and the average 8-10 year government-bond yield (the "long" rate). Inflation n-years ahead was forecast using a linear trend and two lag-years of inflation. Data sources: OECD Business Sector Data Base and IMF *International Financial Statistics*.

[10] Laws and regulations do not capture the full determinants of capital-labor relations. In particular, the severity with which an existing labor code is applied is highly responsive to contingent political pressures. The administrative authorization for dismissals, for example, involved a visit by a "labor inspector" who, at that point, has the discretion to apply the full rigor of the labor code to the totality of the firm's practices, and not simply to the case in question. Based on interviews with inspectors, Berger and Piore (1980) report that their actions were highly responsive to the government's political objectives.

the 1986 lifting of the administrative authorization for dismissals, which is currently on the agenda to be reinstated by the new Jospin government), this phase is primarily characterized by a relative *status quo* in capital-labor relations. Government alternated four times between left- and right-wing coalitions, but the differences between the two had narrowed substantially. Moreover, it has become clear that any reforms that undermined the interests of a major group would be very difficult to pass.[11]

2.3. Some Evidence on Factor Substitution: the Short and the Long Run

How did the institutional shocks described in the previous section shape the path of employment, capital, wages, and profits observed for the French economy? Our explanatory hypothesis is that the economy's response is driven by the interaction of a clear appropriation push with two characteristics of technology: putty-clay investment, and factor substitutability in the technological menu.

In order to examine whether the technological ingredient of our hypothesis is borne out by the data, we start with the simple experiment depicted in figure 2.2. This figure assumes a standard Cobb-Douglas aggregate production function with a capital share $\alpha = 1/3$. We chose the unit-elasticity of substitution assumption inherent in the Cobb-Douglas form not because we have evidence for it — quite the contrary, we argue later on — but because it will prove to be a useful benchmark. Under our assumptions, the ratio of the wage w to the marginal product of labor Y_N is proportional to the labor share:

$$\frac{w}{Y_N} = \frac{1}{1-\alpha}\frac{wL}{Y}.$$

The quantity on the right-hand side is depicted for the business sector in figure 2.2, for France in the top panel and for the US in the bottom.[12] Although French wages were close to the marginal product of labor implied by our assumptions in the late sixties, they grew substantially faster and exceeded that measure in the 1970s. This pattern turned around during the 1980s, and by now wages are substantially below the implied marginal product. The bottom panel portrays a similar series for the US, to illustrate the fact that wages and implied marginal products have tracked each other much more closely there.

Our interpretation of the results in figure 2.2, as developed in the following sections, is that the wage push in the late 1960s and 1970s found a putty-clay aggregate production function with, *effectively*, a very low elasticity of substitution in the short run — much less than unity. In the short run, the economy responds as if the marginal product of labor in existing units were higher than that implied by a Cobb-Douglas assumption, so actual wages can rise higher than our implied marginal product. Over time, as capital is replaced and new technologies can be selected, the effective elasticity of substitution rises, perhaps well above one. Thus sharp substitution away from labor keeps the marginal product of labor from rising as much as implied by a Cobb-Douglas form, and actual wages fall below the implied marginal product.

To explore this hypothesis further, we write the static first-order condition for profit maximization with respect to capital for the more general case of a CES production function with

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[11]Saint-Paul (1993) provides an insightful analysis of the political economy of European labor-market reforms.

[12]Source: OECD Business Sector Database. Labor shares correspond to the ratio of employee compensation over GDP at producer prices, both for the business sector.

Figure 2.2 : The Wage Gap

(a): France; Wage over Y_L (Cobb-Douglas)
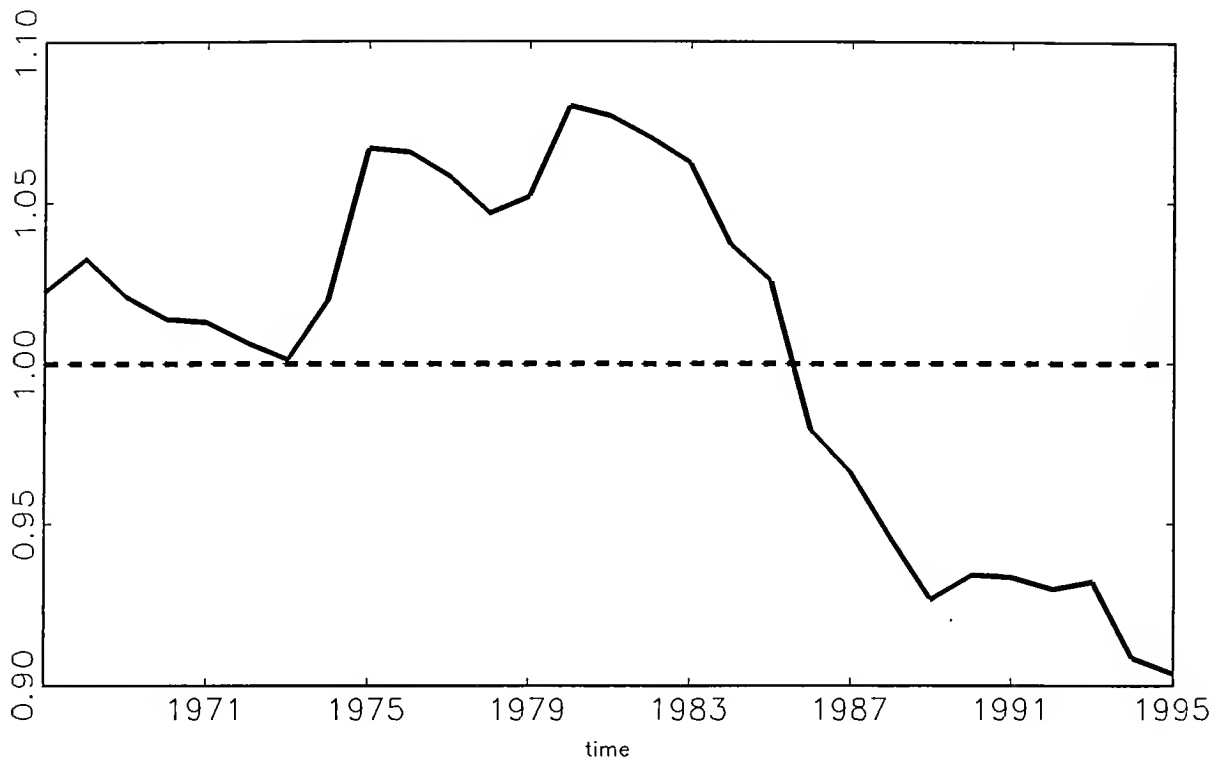
(b): US; Wage over Y_L (Cobb-Douglas)
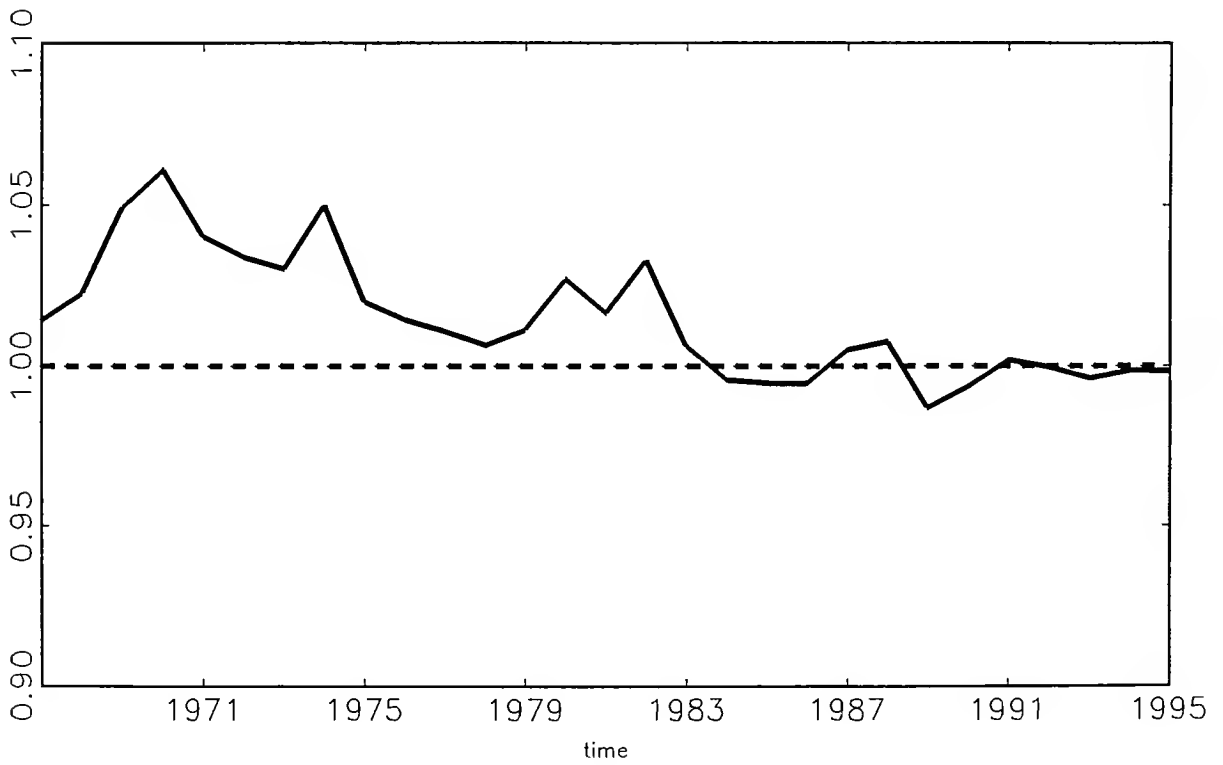
elasticity of substitution σ:

$$\ln c_k = \text{constant} - \frac{1}{\sigma} \ln \frac{K}{Y}, \qquad (2.1)$$

where c_k denotes the cost of capital. If one estimates this equation in levels or first-differences for France, the implied estimate of σ ranges from zero (actually a non-significant negative number) to 0.75, depending on the precise measure of cost of capital (we used measures based on the real 3-month and 8-year rates, as well as profits).[13]

However, if one acknowledges the difference between capital in place and new capital, one must not interpret these results as estimates of the elasticity of substitution for uncommitted capital. For that, one would like to use only the measure of K/Y that corresponds to new production units. A very crude way of constructing such a measure is to assume that a fixed fraction λ of existing production units is scrapped or reorganized every period — including those that fail at a fixed rate δ. In that case, capital in new units is equal to

$$K_t^n = I_t + (\lambda - \delta)K_{t-1}, \qquad \lambda \geq \delta,$$

where I denotes gross investment. Similarly, assuming that technological progress is embodied in new units (which will be an assumption in our model), we can write output in new units as

$$Y_t^n = Y_t - (1 - \lambda)Y_{t-1}.$$

Replacing the K/Y ratio that results from these expressions into (2.1), assuming $\lambda = 0.10$ and $\delta = 0.05$, and re-estimating equation (2.1), yields estimates of σ that range from 2.38 to 6.54, all very significant.[14]

3. Appropriability, Putty-Clay, and Factor Substitution

The model we construct to capture the interactions between appropriation and technology includes the following basic features: *(i)* putty-clay investment and replacement of vintage capital; *(ii)* capital/labor substitution possibilities in the technological menu; *(iii)* an appropriability problem, due to limited pre-contracting abilities, that attempts to capture some basic technological and institutional variables; *(iv)* a fully dynamic structure that allows us to study events at different frequencies. The model is based on Caballero and Hammour (1996a), but differs mainly in that it allows for a choice between technologies with different factor proportions.

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[13] We used annual data for the period 1967-95 from the OECD Business Sector Data Base. Interest rate-based measures of the cost of capital correspond to the real interest rate plus a depreciation and risk-premium constant, set to make the average cost of capital equal to the average profit rate. The construction of real interest rates was described in footnote 9.

[14] To check robustness, we also explored two alternative approaches: *(i)* Estimate equation (2.1) after exchanging the right- and left-hand side variables. The problem is that measures of the cost of capital are much noisier than quantities, so the bias is likely to be larger. In that case, all coefficients are substantially smaller, but we still obtained estimates for marginal units much larger than those for the raw data (the largest estimate with raw data is 0.21, while with "marginal" measures it is 1.80 and highly significant). *(ii)* Similar equations can be estimated for the wage-labor side. The problem is that, first, it is not clear what represents the marginal wage; and, second, if technological progress is labor-augmenting, we have an extra unobservable. Running regressions using the actual wage and time trends repeats our pattern — more pronounced but less precise — for the counterpart of equation (2.1), but not for the reverse regression where nothing is significant if we use marginal measures.

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Our model economy is set in continuous time, with an infinite horizon. It is solved under the assumption of perfect foresight for aggregate variables.[15] There are two factors of production, capital and labor; and a single consumption good, chosen as the numeraire. Aggregate capital and employment at time t are $K(t)$ and $N(t)$; aggregate output is $Y(t)$. The relative supply elasticities of the two factors are central determinants of the general-equilibrium implications of appropriability. Labor supply is assumed fully inelastic, equal to the infinitely-lived labor force $\overline{N} = 1$. With a caveat explained below, the supply of uncommitted capital is assumed fully elastic, and must yield an interest rate $r > 0$. The underlying assumption is that all agents maximize linear utility discounted at rate r.

Technology

We assume putty-clay investment. The *ex-ante* technological menu at time t is characterized by a CES production function with elasticity of factor substitution σ:

$$F(k, A(t)n) = z\left[\alpha k^{1-1/\sigma} + (1-\alpha)(A(t)n)^{1-1/\sigma}\right]^{1/(1-1/\sigma)}, \quad z, \sigma, \alpha > 0, \quad \alpha < 1, \quad (3.1)$$

where k and n represent capital and labor inputs. Labor-augmenting technical progress takes place at rate $\gamma > 0$:

$$A(t) = A(0)e^{\gamma t}.$$

If investment is sunk at time t_0 with a chosen technology, the *ex-post* production function has the *fixed* productivity $A(t_0)$ and the fixed capital intensity $\kappa(t_0) \equiv k \div A(t_0)n$ of the technology chosen at t_0. Our interpretation (and following calibration) of $F(k, A(t)n)$ is as a *technological menu*, which can be thought of as an envelope of possible Leontieff production functions whose technologies can be developed. In order to capture the notion that technologies very different from those currently in use take time to be developed, our simulation introduces an *ad hoc* constraint on the speed at which technologies with new capital intensities $\kappa(t)$ can be developed:[16]

$$\left|\frac{d\kappa(t)/dt}{\kappa(t)}\right| \leq \widehat{\kappa}^{\max}, \quad \widehat{\kappa}^{\max} > 0. \quad (3.2)$$

Productive structure

In order to characterize the productive structure in place, we define a *production unit* created at time t_0 as the combination of one unit of labor and $\kappa(t_0)A(t_0)$ units of capital, that generates a revenue of $A(t_0)F(\kappa(t_0), 1)$. Because they face the same conditions, all production units of a given vintage are identical. At any time t, the economy's productive structure is characterized by a pair of age-distributions $\{n(a,t), \kappa(t-a)\}_{a\in[0,\overline{a}(t)]}$, which denote, respectively, the number (i.e., density) and capital-intensity of units of age a, and where $\overline{a}(t)$ denotes the age of the oldest unit in operation. These distributions fully determine the aggregate stock of capital, employment, and output:

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[15] This simplification is acceptable given our focus on medium-to-long term issues, with a few institutional shocks that we treat as unanticipated. For a related stochastic model, see Caballero and Hammour (1997).

[16] Thus, the technological menu that is immediately available depends on the technologies recently implemented. Note that a technology is determined by $A(t)$ as well as κ, which means that technologies developed in the past with the same κ can be very different if they correspond to a much lower value of A.

$$K(t) = \int_0^{\bar{a}(t)} \kappa(t-a)A(t-a)n(a,t)\,da; \tag{3.3}$$

$$N(t) = \int_0^{\bar{a}(t)} n(a,t)\,da; \tag{3.4}$$

$$Y(t) = \int_0^{\bar{a}(t)} A(t-a)F(\kappa(t-a),1)n(a,t)\,da. \tag{3.5}$$

Creative destruction

In the presence of technical progress, the putty-clay nature of technology necessitates that new units be continuously created to replace outdated units based on obsolete technology. If we denote aggregate capital investment by $I(t) = i(t)A(t)$, the unit-cost of investment is given by

$$\mathrm{c}\,(i) = c_0 + c_1 i, \quad c_0, c_1 \geq 0. \tag{3.6}$$

We denote by $T(t)$ the planned lifetime of a unit created at time t. This function is related to the scrapping age $\bar{a}(t)$ through the perfect foresight assumption, so

$$\bar{a}(t + T(t)) = T(t). \tag{3.7}$$

We also assume a rate $\delta \geq 0$ at which a production unit fails exogenously, before its planned liquidation, and must be scrapped.

Appropriability

One factor may appropriate the other through the existence of specific quasi-rents and incomplete contracting. There are a number of variables, both technological and institutional, that affect the degree to which invested capital is appropriable. At the microeconomic level, we capture this phenomenon by assuming that part of capital invested becomes relationship-specific, in the sense that it is lost if capital separates from labor. If a production unit is created at t, we assume that a part $\bar{\phi}(t)$ of invested capital $\kappa(t)$ is relationship-specific and cannot be pre-contracted upon.[17] This type of specificity may be technological (as in the example of a firm that spends on training its workers; or of firm-specific knowledge embodied in a group of organized labor) or institutional (if it is driven, for example, by right-to-strike legislation).[18]

At the political level, there are various ways in which labor, as an interest group, can attempt to appropriate capital. We introduce three factors that seem of particular relevance in practice, and assume that those institutional restrictions cannot be contracted away. *(i)* Firing costs can be instituted which effectively increase capital specificity. We assume a production unit incurs

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[17] For a discussion of various ways in which the specific component of investment may depend on relative capital and labor use, and of their equilibrium implications in the presence of appropriability, see Caballero and Hammour (1996c).

[18] A solution to the contracting problem is for the worker to finance the part of specific investment he can appropriate. In practice, this is limited by worker wealth, precommitment constraints, asymmetric information about the nature of the investment, control rights issues, etc. The constraint that is perhaps easiest to capture in our model is the wealth constraint, despite our infinite-horizon assumption. As a short-cut, we could simply assume that workers have no access to a saving technology.

a loss of $x^f(t)A(t)$ at the time of a separation decision, but not in case of exogenous failure.[19]
(ii) The *effective* appropriability of capital is also increased by the presence of unemployment benefits, which improve workers' bargaining position by raising the value of their outside option of being unemployed — at least in partial equilibrium. We assume benefits are determined as a fraction $x^b(t)$ of the shadow wage $\tilde{w}(t)A(t)$ defined below. *(iii)* Finally, the appropriation of capital can come through the levying of social charges on firm employment that are then redistributed to workers. We also assume that employment taxes are levied as a given fraction $x\tau(t)$ of the shadow wage: $\tau(t)A(t) = x\tau(t)\tilde{w}(t)A(t)$.[20]

Quasi-rents and equilibrium

We now describe the model's equilibrium conditions, for which a detailed derivation can be found in appendix 6.2. Specific quasi-rents arise as the difference between the value of a production unit, and the *ex-post* outside opportunities of capital and labor. From the firm's view point, a firing cost $x^f(t)A(t)$ must be incurred if it separates from the worker. The firm may decide either to scrap existing capital, or utilize it with a new worker — in which case it would have to employ the same embodied technology chosen at the original time of creation. To replace the worker, we assume that the firm must reinvest the relationship-specific component $\overline{\phi}(t)$ of capital. On the worker's side, separation means joining the unemployment pool to receive the expected "shadow" wage $\tilde{w}(t)A(t)$, which includes unemployment benefits $x^b(t)$.

Therefore, the specific quasi-rents in a production unit that has just been created are equal to

$$
\begin{aligned}
S(t) &= \int_t^{t+T(t)} \left[F(\kappa(t),1)A(t) - \tau(s)A(s)\right] e^{-(r+\delta)(s-t)}ds - x^f(t+T(t))A(t+T(t))e^{-(r+\delta)T(t)} \\
&\quad - \left[\left(\kappa(t) - \overline{\phi}(t)\right)c(i(t)) - x^f(t)\right]A(t) - \int_t^{t+T(t)} \tilde{w}(s)A(s)e^{-(r+\delta)(s-t)}ds.
\end{aligned}
\tag{3.8}
$$

The expression on the first line captures value-added in the production unit; the two expressions on the second line subtract the outside opportunities of capital and labor, respectively. Assuming no pre-contracting possibilities and generalized Nash bargaining, each factor gets the value of its outside opportunity plus a share of the quasi-rents. We denote the share of labor by β, and that of capital by $(1-\beta)$.

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[19] Firing restrictions give rise to complex regulatory and bargaining considerations. One can distinguish between a pure severance *transfer* component, that does not constitute a loss for the production unit as a whole; and a pure *deadweight-loss* component. The former typically takes the form of a transfer from capital to labor that increases with the length of the employment relationship. The latter is the result of inefficient bargaining (due to asymmetric information), as well as a multitude of regulatory restrictions (notification periods, proofs of cause of dismissal, administrative authorizations for dismissals, etc.). Emerson (1988) reports that, according to a 1985 European Commission survey, "the financial cost of redundancy payments was in all countries considered to be a less important problem than the length of notice periods and the difficulty of legal procedures. This is particularly so in the case of France" (pp. 791-2).

Our model assumes firing costs are of the second type. A main advantage of that type of firing cost is to capture the delayed-separation effect of firing restrictions. Under our assumption of efficient bargaining, this effect does not arise with pure severance transfers. (See Mortensen 1978 for an early treatment of the efficiency of separation in the presence of specific capital).

[20] This is done for simplicity. A more realistic assumption is to make τ a function of the *total* wage payment, but it is a costlier assumption to implement in our numerical simulations. With the parameters we calibrated for France, the equilibrium wage premium is only around 5 to 10 percent of the shadow wage, which is small relative to the change in French payroll taxes observed during our period of study.

The appendix shows how this present-value split yields a path of *actual* wage payments $w(t; t_0)A(t)$, at time $t \in [t_0, t_0 + T(t_0)]$ for a unit created at time t_0, consistent with continuous-time bargaining. Generally speaking, wage payments $w(t; t_0)A(t)$ will be equal to the worker's outside opportunity cost (or shadow wage) $\widetilde{w}(t)A(t)$ plus a quasi-rent premium.[21] The shadow wage itself can be expressed as a function of labor-market conditions and outside possibilities for rent appropriation. Assuming all gross hiring $H(t)$ is made from the unemployment pool $U(t) = 1 - N(t)$,

$$\widetilde{w}(t)A(t) = \frac{H(t)}{U(t)}\beta S(t) + x^b(t)\widetilde{w}(t)A(t). \tag{3.9}$$

The shadow wage is equal to the probability-rate of finding a job times the resulting increase in human wealth, plus unemployment benefits.

Aggregate investment, scrapping, and the capital intensities are the result of free entry and optimization on the part of firms. Assuming *free entry* in the creation of production units implies that the firm's share of quasi-rents should compensate it for the specific investment it is sinking into the production unit:

$$\overline{\phi}(t)c(i(t))A(t) + x^f(t)A(t) = (1 - \beta)S(t). \tag{3.10}$$

Value maximization by the firm implies that separation will take place when the unit reaches a scrapping age $\overline{a}(t)$ that satisfies the *exit condition*

$$F(\kappa(t - \overline{a}(t)), 1)A(t - \overline{a}(t)) = (\widetilde{w}(t) + \tau(t))A(t) - \left[(r + \delta - \gamma)x^f(t) - \frac{dx^f(t)}{dt} \right]A(t). \tag{3.11}$$

The revenues of a production unit at the destruction margin should equal the (after-tax) shadow wage of the worker minus a term that measures the benefit of delaying the deadweight firing cost. Value maximization also implies that, as long as constraint (3.2) is not binding, capital intensity $\kappa(t)$ is determined by the following *first-order condition*:

$$\int_t^{t+T(t)} \frac{\partial F}{\partial n}(\kappa(t), 1)A(t)e^{-(r+\delta)(s-t)}ds$$
$$= \int_t^{t+T(t)} [w(s, t) + \tau(s)]A(s)e^{-(r+\delta)(s-t)}ds + x^f(t + T(t))A(t + T(t))e^{-(r+\delta)T(t)}. \tag{3.12}$$

In present-value terms, the marginal revenue-product of labor is set at the marginal labor cost — including actual wage payments, social-security charges, as well as future firing costs.[22]

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[21] Briefly put, at any time t, there is an age threshold $a^*(t) \in (0, \overline{a}(t))$ for production units such that all units younger than $a^*(t)$ would find it profitable to re-hire a new worker if they separate from their current worker, while more obsolete units would not. For units younger than $a^*(t)$, the maximum loss a worker can cause is limited to his replacement cost. As a consequence, the quasi-rent premium in $w(t; t_0)A(t)$ is proportional to an "annuity" value of this replacement cost. For units older than $a^*(t)$, since the unit's value would drop to zero if the worker leaves, all capital is effectively specific to the relationship. The wage premium in this case is, essentially, a fraction of the flow quasi-rents.

It is interesting to note the implicit "profit-sharing" implications of this rule. In young units ($a < a^*$), capital is the "residual claimant" of all shocks that do not directly affect $\widetilde{w}$ or the worker's replacement cost. In older units ($a < a^*$), part of those shocks is absorbed by wages.

[22] The notion that factor proportions are determined by capital rather than labor is due to the fact that, under our assumptions, labor is the appropriating factor and therefore exhibits a segmented market (Caballero and Hammour 1996c).

Basic properties

Equilibrium in this type of economy is characterized by a number of properties, as discussed in Caballero and Hammour (1996a, 1996c). Generally speaking, the appropriating factor — labor in our model — will be underemployed; and will experience market segmentation (involuntary unemployment $U > 0$), while the other factor's market clears. Appropriability leads to excessively slow renovation and technological "sclerosis." It also results in a "decoupling" between creation and destruction flows, with excessively high destruction and low creation in recessions leading to a surge in unemployment. Finally, under our assumptions, appropriability causes excessive capital-labor substitution. This can easily be seen from equation (3.12), which shows that the capital/labor ratio is chosen based on *actual* wage payments — which include a rent component — as opposed to the private shadow cost of labor, $\tilde{w}$.[23]

The model presented in this paper focuses on a single direction of appropriability, from labor to capital. More generally, with bilateral specificity, which factor effectively appropriates the other depends on which one sinks a greater value into joint production. This is determined by the relative degrees of technological and institutional specificity, the two factors' relative supply elasticities, and aggregate conditions. Moreover, with bilateral specificity, labor (the less elastic factor) will be the appropriating factor and its market will be segmented (giving rise to involuntary unemployment) during unfavorable aggregate conditions; while capital (the more elastic factor) will be the appropriating factor and its market will be segmented (giving rise to labor shortages) during favorable conditions. This is why, in section 2, we interpret the 1960s as a booming period with labor shortages and essentially no appropriation of capital; and the labor movement of the late 1960s as a response to the relative balance of appropriability that favored capital at the time.

4. Technological Dimensions of Appropriability

4.1. Parameter Choice

Because the concrete case we chose to study is France, we set our simulation parameter values to fit the French situation. We assume that France was roughly in steady state equilibrium around 1967. We set technological and institutional parameters to fit that "initial" situation, then describe a path for the institutional parameters that captures, in a very stylized manner, the ensuing appropriability shocks.

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[23] From a social point of view, substitution is even more distorted, since the social shadow wage in our model is zero in the presence of unemployment. Moreover, in models with bilateral specificity, one can get excessive substitution even with respect to actual wages (rather than shadow wages), beyond that obtained here due to the dead-weight loss x^f associated with separations.

13

TABLE 4.1 BASIC PARAMETERS

Interest Rate (r)	0.06
Growth Rate (γ)	0.04
Failure Rate (δ)	0.08
Technological Substitution (σ)	6.00
Capital Share	0.34
Maximum Technical Change ($\widehat{\kappa}^{\max}$)	0.05
Capital/Output Ratio	2.60
Slope of Investment Cost (c_1)	2.00

Basic parameters

Our approach to setting the model's basic parameters, that correspond to the initial steady state, is summarized in table 4.1. We assumed a real interest rate $r = 0.06$ and a rate of labor-augmenting technical progress $\gamma = 0.04$.[24] We set the failure rate at $\delta = 0.08$, which lies between the standard depreciation rates used for structures and equipment. Together with the active scrapping rate that results from our parameter choices (see below), this adds up to an effective depreciation rate closer to the standard rate for equipment — which better fits to the concept of capital in our model.

Technological menu (3.1) is determined by three parameters: σ, α and z. Because our argument depends on a significant degree of technological substitution, we set $\sigma = 6.0$. As we argued in section 2.3, this value is empirically consistent with much lower short-run substitutability in the "aggregate production function."[25] We set $\alpha = 0.210$, which yields a steady-state capital share of 0.34 consistent with that observed for France in the late 1960s.[26] We normalized aggregate output to 1.0 in the initial steady state by normalizing $A(0) = 1$ and setting the aggregate productivity term $z = 1.088$. The upper-bound (3.2) on the speed of technical change avoids high-frequency jumps to entirely new technologies in our simulations, and slows down the speed of technological adaptation to shocks. We chose a maximum annual rate for $\widehat{\kappa}^{\max}$ of 5.0 percent.[27]

The capital series reported in national accounts do not take into account time-variations in the scrapping rate. For comparability, our simulations report a "constructed" capital counterpart, that we define as cumulative investment depreciated at an exponential rate of 5.2 percent.[28]

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[24] Wolff (1986) estimates that French total factor productivity growth over the period 1960-73 was 2.7 percent. Dividing by the labor share, this implies a value for γ around 4 percent in the initial steady state. We did not attempt to capture effects of the productivity slowdown in our simulations.

[25] This is all the more true if we recognize the time it takes to develop technologies, as captured by our assumed upper-bound (3.2) on the speed of technical change.

[26] Note that, even in the Cobb-Douglas case ($\sigma = 1$), the vintage structure does not allow us to set α directly equal to the capital share. There are two reasons for this. Recall that first-order condition (3.12) sets the present value of the marginal product of labor equal to the present value of employee compensation plus separation costs. First, the measured share of labor aggregates over wages paid to *existing* cohorts, rather than over the discounted flows of future payments to a *given* cohort. Second, the cost of labor includes a waste term (firing costs) that is not part of employee compensation.

[27] This upper bound is never binding in the sample if we construct rough annual estimates for $\widehat{\kappa}$ based on the assumptions in section 2.3.

[28] Exponential depreciation is clearly only an approximation to the richer depreciation schedules used to construct capital series. For French data in the 1970s, the implicit average service life of capital is 33 years for structures; and

We set the cost of investment $c = c_0 + c_1 i$ in the initial steady state to 1.357, which yields a constructed capital/output ratio equal to the 2.6 ratio reported for France in the late 1960s. In terms of the argument presented in this paper, the importance of the specific decomposition between c_0 and $c_1 i$ lies in determining the effective elasticity of capital supply in the long run. This, in turn, determines possibilities for long-term appropriation (see section 4.2). We chose a value $c_1 = 2.0$, which implies a capital-supply elasticity of 2.9 in the initial steady state.

Labor-market institutions

The highly stylized path depicted in figure 4.1 for the model's institutional parameters is intended to capture the French situation, as described in section 2.2. Breaks in the path of those variables in 1968, 1975, 1981 and 1986 are taken as surprises in the simulation.[29] In order to limit the number of surprises, we concentrated shocks in a few years, and shifted events by a year or two to make them coincide. Table 4.2 summarizes the values we chose for the initial steady state, as well as the final value reached by each parameter.

TABLE 4.2 INSTITUTIONAL PARAMETERS

	Initial	Final
Bargaining Share (β)	0.50	0.50
Specificity ($\bar{\phi}$)	0.00	0.11
Firing Cost (x^f)	0.11	0.25
Unemployment Benefits (x^b)	0.25	0.37
Social Security Contributions (x^τ)	0.26	0.39

We set the Nash-bargaining parameter symmetrically at $\beta = 1/2$ throughout the period. The path of unemployment benefits, $x^b(t)$, and social security contributions, $x^\tau(t)$, were set to match the data in a stylized manner.[30] Measures of the unemployment benefit replacement ratio in France increased gradually from 0.25 to 0.37 between 1975 and 1987. The employment tax rate also increased, from approximately 0.26 in 1967 to 0.39 in 1990.[31] This increase is captured in three unanticipated steps in the path of $x^\tau(t)$.

Given the above variables, the remaining institutional parameters — specificity $\bar{\phi}$ and firing costs x^f — determine the creation and sharing of specific quasi-rents, and, therefore, equilibrium hiring and unemployment. For the initial steady state, we chose those variables so as to get an unemployment rate $U = 0.028$ (around the level of French unemployment in the late 1960s) and a gross job creation rate $H/N = 0.11$ (roughly, the average churn rate in the US).

The jumps in $\bar{\phi}$ and x^f in the years 1968, 1975, 1981 and 1986 are designed to capture events during phases II to IV described in section 2.2. Those two variables have similar long-term effects, and are not easily disentangled.[32] We fixed the total increase in those variables

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12 years for plant and equipment (Keese et al. 1991, table 2, p. 14). The average service life for the depreciation rate we used is 19 years, and lies somewhere in between.

[29] For example, until 1975 agents forecast the equilibrium path of the economy with the expectation that x^f will remain permanently at 0.11. In 1975, they revise their forecasts, with the expectation that x^f will remain permanently at 0.25.

[30] Source: CEP-OECD (1950-1992) dataset.

[31] We define the employment tax rate as employer social security, private pension and welfare plan contributions, over the difference between employee compensation and the previously mentioned employer contributions.

[32] The method used in the previous paragraph is not robust. It is model-specific, and is sensitive to the measurement of the economy's churn rate — which is fraught with conceptual and data difficulties.

Figure 4.1 : Institutional Shocks

[a]: φ

[b]: x^f

[c]: x^τ

[d]: x^b
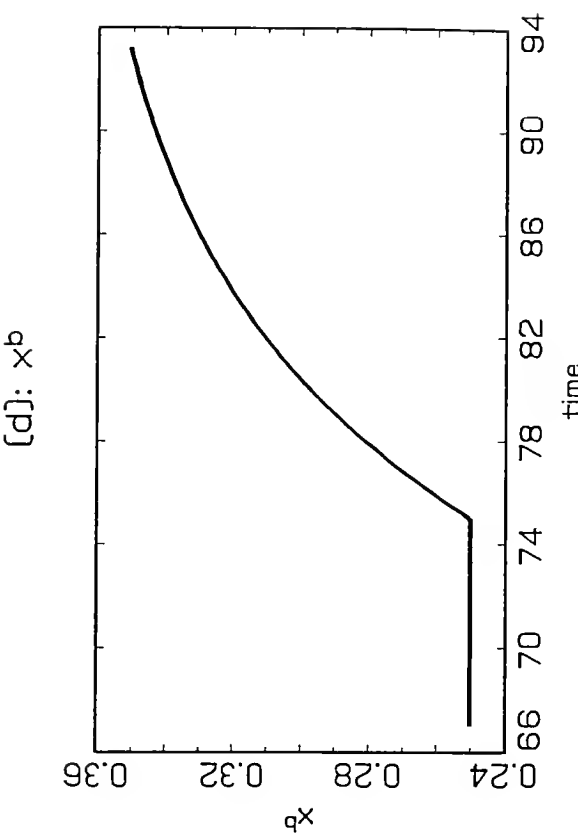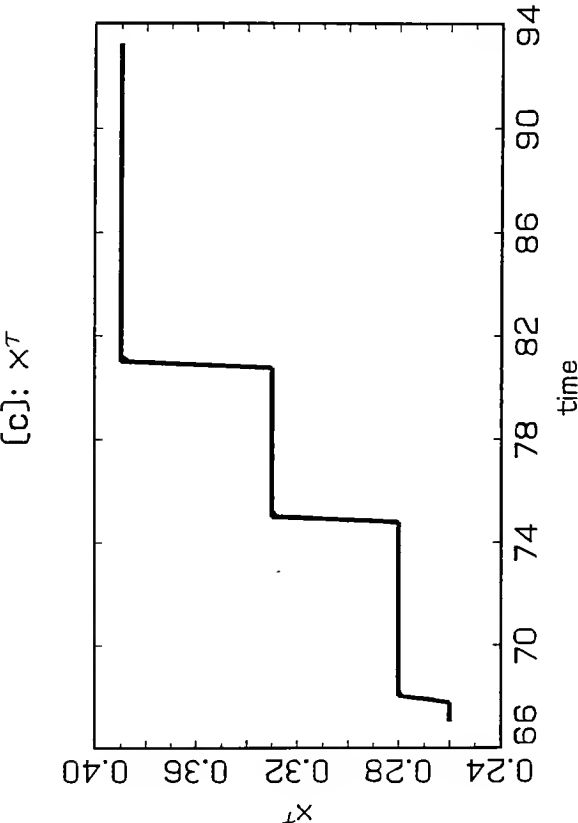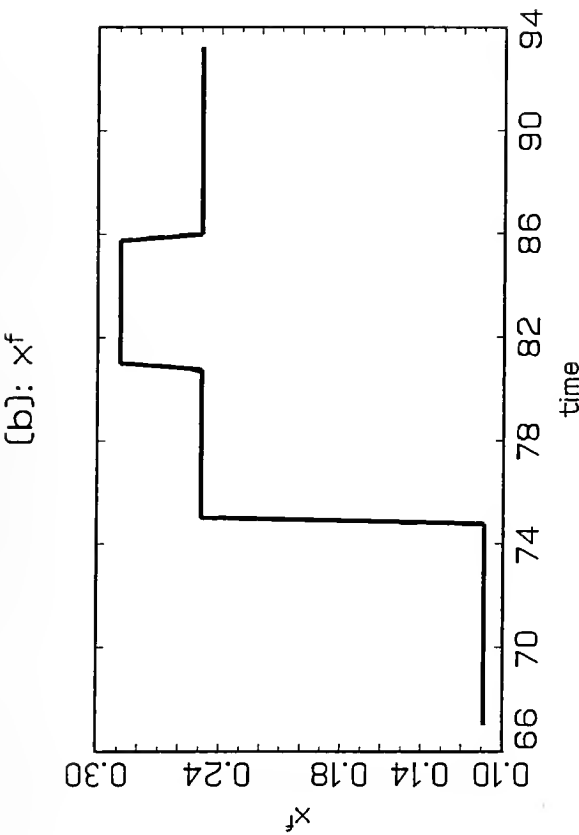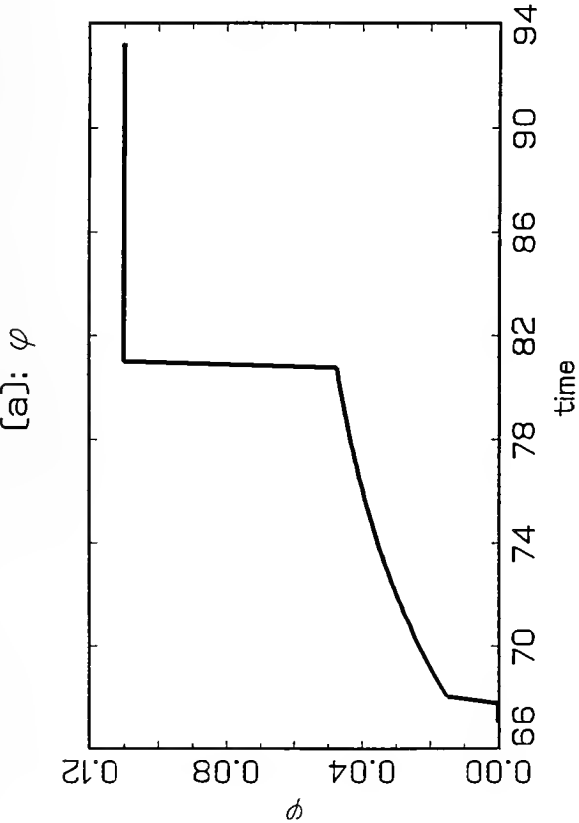
to be such that — combined with the increases in x^b and x^τ — it yields a final steady-state unemployment rate around 12 percent, with each of $\overline{\phi}$ and x^f contributing roughly equally to this increase. Specificity increases from $\overline{\phi} = 0.00$ to a final value of 0.11, which amounts in the final steady-state equilibrium to about 3 percent of investment. Firing costs increase from $x^f = 0.11$, the equivalent of 1.9 months of a worker's compensation in the initial steady state, to a final value of 0.25, equivalent to 4.4 months of compensation in the final steady state.

4.2. Appropriation in the Long Run

We start with a *long-run* analysis of the interactions of appropriability and technology in general equilibrium, that compares steady states with different degrees of appropriability. Table 4.3 presents the value of a number of aggregates for an "initial" steady state that corresponds to the institutional parameters calibrated for France in the late 1960s; and a "final" steady state with the institutional parameters calibrated for the early 1990s.[33] In order to highlight the effects of technology choice, we present results for an economy where technology remains unchanged (κ fixed) and for the economy with adapting technology (κ varies). From here on, variables with a γ-trend (wages, output, investment, etc.) are reported and discussed in detrended terms.

TABLE 4.3
LONG-RUN EFFECTS OF APPROPRIATION

	Initial	Final	
		Technology Fixed	Technology Adjusts
Unemployment (U)	0.027	0.120	0.119
Hiring (H)	0.106	0.093	0.086
Shadow Wage ($\tilde{w}$)	0.548	0.481	0.464
Compensation/Worker	0.703	0.714	0.689
Labor Share	0.692	0.712	0.639
Scrapping Age ($\bar{a}$)	16.26	17.53	20.81
Capital Intensity (κ)	2.18	2.18	2.87
K/Y Ratio	2.54	2.50	2.85
Investment (i)	0.231	0.202	0.247
Output (Y)	0.987	0.882	0.949

It is clear that the appropriation shocks worsen the functioning of the labor market, causing higher unemployment and lower hiring. Because of the increase in unemployment duration, the opportunity cost of labor $\tilde{w}$ falls, which reduces pressure to scrap obsolete units and causes an increase in technological sclerosis (i.e., a higher scrapping age $\bar{a}$). With technology choice, firms choose to reduce their exposure to appropriation by decreasing the labor-intensity of production units, causing an increase in the capital/output ratio. The long-term effect is to limit appropriation possibilities, making it difficult for average employee compensation to rise (actually causing

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[33] Note that variables in the initial steady state take slightly different values from those used to calibrate the model. The reason is that calibration was based on an exact continuous-time solution for the steady state; while table 4.3 reports computations based on a time discretization intended to be fully comparable with the dynamic simulations presented in the next section.

it to fall with our parameter values) and resulting in a fall rather than an increase in the labor share. The rest of this section analyzes the precise mechanisms behind those effects.

Wages, unemployment and productivity

Let us first start with the effect of appropriability with a *fixed technology*. The long-run equilibrium outcome is determined by free-entry condition (3.10), which can be re-written as

$$
\begin{aligned}
c(i(t))\kappa(t) &= \int_t^{t+T(t)} F(\kappa(t), 1)A(t)e^{-(r+\delta)(s-t)}ds \\
&\quad - \int_t^{t+T(t)} [w(s,t) + \tau(s)]A(s)e^{-(r+\delta)(s-t)}ds \\
&\quad - x^f(t+T(t))A(t+T(t))e^{-(r+\delta)T(t)}.
\end{aligned}
\tag{4.1}
$$

This condition equates the creation cost of a production unit to the present value of value-added minus labor costs (equal to wages, social security contributions, and firing costs).

What is the effect of an increase in the appropriability parameters in table 4.3? Suppose first that both the price c of capital and the lifetime T of a production unit remain constant. It is clear then from equation (4.1) that, with fixed technology (i.e., constant κ), labor costs cannot rise in equilibrium. The increase in the appropriability of capital is offset, in general equilibrium, by a fall in hiring and a rise in unemployment, that reduce the outside opportunity $\tilde{w}$ of labor. The equilibrium level of unemployment is what is needed to guarantee capital its market return, which undermines whatever advantage labor was able to obtain through political intervention in labor-market institutions.

The reason appropriation attempts in the above argument are entirely unsuccessful is the perfect long-run elasticity of the supply of capital. The notion of a capital supply that is less than perfectly elastic can be roughly captured with an increasing $c(i)$ function (think of it as the price of capital goods).[34] In that case, as investment falls, the price of capital falls, and the part of value added in equation (4.1) that must go to capital also falls. Some increase in labor costs is possible in general equilibrium, and appropriation attempts can be partly successful. As can be seen in the table, compensation per employee and the labor share can rise. Nevertheless, because capital remains highly elastic, the institutional shocks in the table will generate a significant increase in unemployment.

Appropriability does not simply affect the sharing of value added in the productive sector, it also affects its productivity through resource misallocation. In our model, resource misallocation takes the form of a higher production-unit lifetime T, which our analysis has so far treated as constant. Since the equilibrium shadow wage $\tilde{w}$ must decline in response to the appropriability push, there will be lower pressure on less productive units to shut down and, by exit condition (3.11), the scrapping age $\bar{a}$ (equal to T in steady state) will rise. This "sclerosis" effect of appropriability has a negative effect on average compensation per employee: in the cross-section, the extra years added to production units necessarily must pay lower wages than in the initial steady state, since units were unable to survive that long at initial wages. The reduced-efficiency effect of appropriability is quite general, and could arise through sectoral misallocation as well as through technological sclerosis, as in our specific example. In the same way that elastic capital

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[34] A more attractive way of modeling imperfectly elastic capital is to assume a partly closed economy, or that some types of capital (like land) are immobile.

thwarts appropriation in the long term, preventing wage increases through higher unemployment, it also causes labor to bear most of the cost of reduced productivity. However, with the parameters behind the fixed-technology column of table 4.3, this negative effect on wages does not fully offset the wage gains from increased capital appropriation.

Labor exclusion

Let us now allow for technology choice, and focus on the last column of table 4.3. In that case, capital intensity is determined by first-order condition (3.12), which sets the present value of the marginal product of labor equal to the present value of labor costs. In response to an appropriation shock, the partial-equilibrium response is to increase the capital intensity κ of units. This puts free-entry condition (4.1) in disequilibrium, which can be rewritten as

$$c(i(t)) = \int_t^{t+T(t)} F_k(\kappa(t), 1) A(t) e^{-(r+\delta)(s-t)} ds, \qquad (4.2)$$

taking account of (3.12) and the constant-returns nature of technology (3.1). In order to make it worthwhile again for capital to enter, either the expected lifetime T must rise (allowing capital to recoup its investment over a longer period) or investment i must fall (reducing the cost c of investment). In the latter case, it is easy to see that T must rise as well, because lower i requires even lower hiring (given that κ rises); which, in turn, implies a lower opportunity cost $\tilde{w}$ for labor, and reduced pressure on obsolete units to exit. In any case, the appropriation shock leads to a misallocation of resources, which has a negative effect on the average cross-sectional wage.

Looking at the last column of table 4.3, capital intensity and the capital/output ratio rise in response to appropriation. With our specific parameters, the free-entry condition is re-equilibrated exclusively through an increase in the scrapping age (equal to T in steady state), which comes through a reduction in hiring and the shadow wage. Investment actually rises, as increased capital-intensity more than offsets the effect of lower hiring.[35] Because of this, technological substitution *per se* does not cause a rise in unemployment beyond the fixed-technology level. This conclusion is not robust, and would be overturned with different parameters or model specifications that cause investment to fall, and put less weight on the endogenous rise in T (as in Caballero and Hammour 1996c).[36]

Technological substitution limits appropriation possibilities by causing the opportunity cost $\tilde{w}$ of labor to fall. Combined with the effect of misallocating resources in low-productivity (high T) units, this causes average compensation per employee to fall compared to the initial steady state. This is paradoxical, given the rise in capital intensity, whose *raison d'être* is an increase in labor costs. The difference is, first, that capital intensity is a function of the discounted value of future labor costs for a *given* vintage of capital; while compensation per employee averages payments for a cross-section of *existing* vintages. Second, the firing-cost component of labor

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[35] Although our steady-steady state results capture the long-run increase in the French capital/output ratio, the increase in investment is not consistent with the French experience. Over the long run, those two measures are closely related through the relationship $I/Y = (\gamma + \delta^m)K/Y$, where γ is the economy's growth rate and δ^m approximates the depreciation rate used to construct the capital series. The fact that we are able to match the long-run change of K/Y but not of I/Y means that the factor $(\gamma + \delta^m)$ must have changed. To match the two measures, one would have to introduce a "productivity slowdown" in γ.

[36] To give another example, a minimum wage would make the scrapping of low-productivity units less endogenous, and effectively act as if T were constant.

18

costs is a dead-weight loss that is not part of employee compensation.[37]

Institutional interactions

How much does each of the stylized institutional shocks we calibrated for France account for in terms of the long-term increase in unemployment? Table 4.4 decomposes, for the case with technological adjustment, the difference between the initial and final steady-state unemployment rates into the difference due to the change in each institutional parameter added separately, and that due to the interaction between the parameters.

TABLE 4.4
INSTITUTIONAL INTERACTIONS

	Effect on U
Initial U	0.027
$\Delta\bar{\phi}$	0.036
Δx^f	0.032
Δx^τ	0.003
Δx^b	0.005
Interaction	0.016
Final U	0.119

Increases in specificity $\bar{\phi}$ and firing costs x^f have the largest effects on unemployment. As explained in section 4.1, those two shocks have similar effects and are difficult to disentangle. Their relative magnitudes were chosen so that they end up having a similar contribution to the increase in unemployment. The effect of firing costs on unemployment are consistent, e.g., with the panel-data evidence in Lazear (1990) documenting the potentially large impact of severance restrictions on unemployment. Other models in the literature conclude that firing costs have an ambiguous effect on unemployment, and most often reduce it. One such line of research removes firing costs from bargaining and wage considerations, emphasizing only the tax aspect of these costs.[38] Another line emphasizes the protective effect of firing costs in response to *transitory* adverse shocks, preventing a type of temporary unemployment which is less relevant to the medium-to-long term analysis conducted here.

The next most important source of unemployment in the table is the interaction term. One can divide our institutional variables into two groups: those that directly increase the specificity

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[37]Asume $\delta = 0$ for simplicity, and normalize $A(0) = 1$. In steady state, the labor cost that is set equal to $\partial F/\partial n$ in (3.12) for a unit created at time zero can be written as

$$\int_0^T \theta(t)(w(t;0) + \tau)e^{\gamma t}dt + x^f e^{-(r-\gamma)T}, \quad \theta(t) = \frac{e^{-rt}}{\int_0^T e^{-rs}ds}.$$

On the other hand, since $w(0; -t) = w(t; 0)$ in steady state, average employee compensation at time zero is

$$\frac{1}{T}\int_0^T (w(t;0) + \tau)dt.$$

The first expression can be greater than the second for two reasons. *(i)* Compensation for a given vintage includes a growth term γ, which is not present in the cross-section. It is easiest to see how this makes the first expression greater than the other when $r = 0$. *(ii)* The first expression includes a firing-cost term that is not in the second.

[38]E.g., Bentolila and Bertola (1990), Bertola (1990).

of investment (namely, $\overline{\phi}$ and x^f); and those that indirectly "leverage" off existing specificity to strengthen the bargaining position of labor (x^b and x^τ). In our model, the latter variables would create no unemployment if the former were inexistent.[39] The interaction term is precisely due to this leveraging off increased specificity. This interaction is crucial in the design of labor-market reforms, which must give priority to the primitive sources of specificity ($\overline{\phi}$ and x^f), and treat the reform of other institutions as mostly complementary.[40]

4.3. Putty-Clay and Factor Substitution: Dynamic Response

The wage push and dynamic factor substitution

We now turn to the *dynamic* effect of appropriation shocks. Figure 4.2 illustrates the path of different aggregates following an unanticipated permanent jump in $\overline{\phi}$, of the same magnitude as that in the above steady-state experiments. The other institutional variables were fixed at the final values they take in those experiments. Dashed lines correspond to the case where technology is kept fixed; while solid lines correspond to the case where technology adjusts. All series are presented in deviation from their pre-shock values.[41]

In both fixed- and flexible-technology cases unemployment jumps after the shock, and keeps climbing well thereafter. Compensation per worker rises rapidly and substantially upon the shock's impact. The counterpart for firms is a drop in the profit rate. Because of putty-clay technology, capital in place is highly vulnerable to appropriability. However, as new capital is invested, it obtains in equilibrium a return commensurate with the cost of capital, and the profit rate recovers to its initial level. The mechanism by which this happens is a fall in hiring and rise in unemployment, which deteriorate labor's employment opportunities and cause a reduction in wages.

Unlike the fixed-technology case, the economy with technological substitution is characterized by progressive capital deepening, as manifested in the rising K/Y ratio. The short-run impact of both scenarios on wages and profits is similar; but substantial differences arise in the long run, when technological substitution possibilities can be fully exploited. With substitution, wages fall faster and lower and profits recover more rapidly. In fact, capital deepening causes compensation per employee to return near its original level, while unemployment keeps climbing — causing the tradeoff between wage levels and unemployment to disappear. Both the lower wages and higher capital intensity associated with technological substitution affect the labor share. After increasing with higher wages in the short run, the labor share drops by much more than in the fixed-technology case, and ultimately falls below its original level. Finally, substitution causes output to benefit from more sustained investment levels, and fall by less than in the fixed technology case.
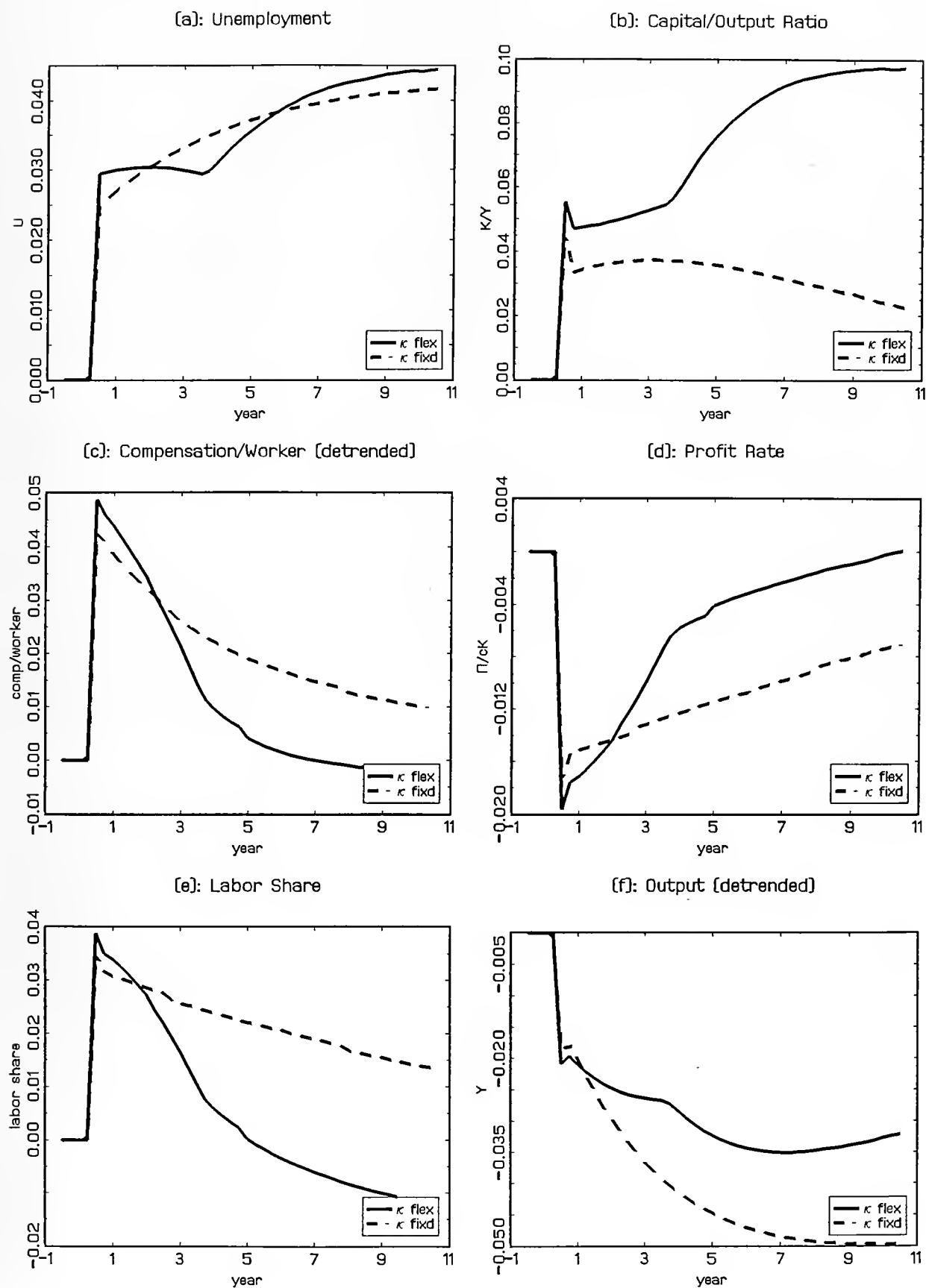
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[39] If there were no specific investment in our model, unemployment benefits would have no effect on equilibrium as long as the replacement rate is less than one; and social-security taxes would be offset one-to-one by lower wages.

[40] Coe and Snower (1996) argue that labor market reform, to be effective, must involve the simultaneous removal of many labor market institutions to exploit their complementarities. Our point is related but not identical, for we argue that there are a set of key institutions over which the others compound their effects.

[41] Briefly, our equilibrium solution method is as follows. Given a history $\{n(a,0), \kappa(a,0)\}_{a\geq 0}$ at $t=0$, an equilibrium is essentially a path $\mathcal{E} = \{i(t), \widetilde{w}(t), \kappa(t)\}_{t\geq 0}$ that satisfies equilibrium conditions (3.10)-(3.12) with compatible rational expectations $\{T^E(t), \widetilde{w}^E(t)\}_{t\geq 0}$. We used an iterative method that starts with arbitrary expectations, solves for the path $\mathcal{E}$, updates expectations based on $\mathcal{E}$, solves again for $\mathcal{E}$, etc., until convergence.

Figure 4.2 : Response to an Appropriation Shock

(a): Unemployment

(b): Capital/Output Ratio

(c): Compensation/Worker (detrended)

(d): Profit Rate

(e): Labor Share

(f): Output (detrended)

Experiment based on the French experience

We now put together the combined appropriability shocks designed to capture the French experience, as depicted by figure 4.1 in section 4.1. The main macroeconomic effects are presented in figure 4.3, which provides a model counterpart for each of the French data series presented in panels (a)-(e) of figure 2.1. Results correspond to the case with technological substitution. It must be expected that the abruptness and unanticipated nature of our shocks would generate "jerky" time series.

The patterns that emerge from the model are certainly reminiscent of the French experience, and, with different speeds and magnitudes, that of other major European economies. Unemployment rises following each appropriability shock, then keeps climbing afterwards. Progressive capital deepening takes place along the path. Compensation per employee — detrended by γ — and the labor share rise after each shock, but decrease thereafter and ultimately fall beyond their initial levels. The profit rate declines after the shocks, then initiates a recovery.

Changing aggregate conditions

Our account of the European experience has, so far, ignored the role of changes in aggregate conditions — oil shocks, monetary and fiscal policy shocks, etc. The effect of those shocks complements the account we have given for the time-series dynamics of an economy like France; but hardly constitute an *alternative* explanation for the dynamics features of wages, profits, factor intensities, and unemployment highlighted above.

The French economy has clearly gone through cyclical fortunes during our period of study, associated with the oil shocks of the 1970s, the high interest rates of the 1980s and 90s, and the expansion of the late 1980s. Although much of the secular increase in unemployment took place during recessions, this obviously does not constitute evidence of causality — one would expect precisely that pattern from an independent combination of trend and cycles. If one is to build an argument that aggregate shocks are the culprit in the buildup of unemployment, one either relies on the effect of transitory shocks becoming permanent through "hysteresis" mechanisms; or on the idea that Europe has suffered a permanent depression.
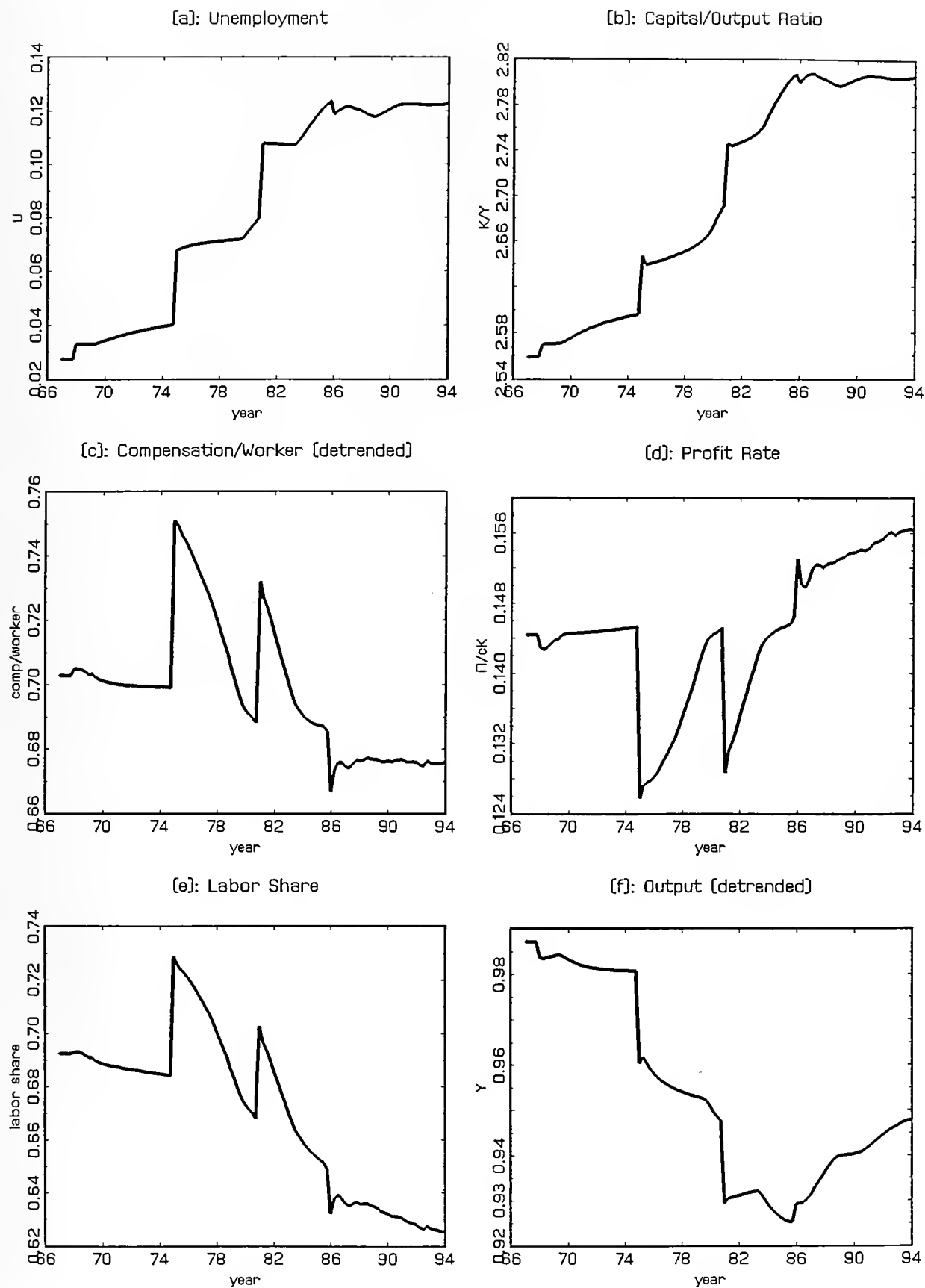
Given the two recessionary oil shocks, it is difficult to explain the continued fast growth of real wages in the 1970s without an appropriation push in mind. That is what led analysts of that period to infer that the rise in unemployment was of the Classical type. The slowdown of wage growth in the 1980s makes a Keynesian account for unemployment more sustainable. However, such an account would be unable to explain why the full recovery of the profit rate during that period was accompanied by an increase — rather than a decrease — in unemployment. Moreover, one would expect the depressed conditions of the 1980s, with the associated high interest rates and slowdown in wages, to cause a substitution away from capital. However, despite those conditions and despite the resulting episodes of low investment, the increasing capital/output ratio indicates a trend toward substitution away from labor.[42]

Factor substitution possibilities raise a warning on policy proposals that stem from a view of European unemployment as mostly a symptom of contractionary monetary and fiscal policy. The expansionary effects of looser monetary policy may benefit investment much more than employment, if lower interest rates result in further substitution toward capital.

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[42]The relationship between evidence on investment and the capital/output ratio was analyzed in footnote 35.

21

Figure 4.3 : Simulation Based on France

[a]: Unemployment

[b]: Capital/Output Ratio

[c]: Compensation/Worker [detrended]

[d]: Profit Rate

[e]: Labor Share

[f]: Output [detrended]

5. Closing Remarks

The institutional buildup we have documented for France has offered us the possibility to trace the macroeconomic response to appropriability at different frequencies. As an explanation of the French experience in the last thirty years, the appropriation push provides a highly parsimonious account; it allows us to offer a unified explanation for the path of a number of key aggregates which, far from having moved in tandem, experienced dramatic changes in their comovements. More traditional accounts of European unemployment based on "aggregate shocks" or purely classical mechanisms are unable to do so.

Although we have focused in this paper on the effects institutional shocks, our analysis applies beyond. Other types of shocks may affect the economic environment, and make it incompatible, in terms of efficiency, with existing institutions. For example, it is likely that factor substitution possibilities in Europe were enhanced by the globalization trend that had been taking place during our period of study. Aggregate substitution possibilities do not only depend on available technologies, but also on the characteristics of demand for the range of producible goods. Globalization increases the potential for specialization — and, hence, factor substitution — by giving firms access to new markets; it also broadens the technological menu by facilitating international technology transfers. The result can be an improvement in investment and growth; but labor may not share in the benefits if its market is heavily regulated. We have seen that greater substitution possibilities can lead to lower earnings for workers, and a stagnant or deteriorating employment outlook.

The recent experience of a country like Argentina fits well with this perspective. Although Argentina has a long tradition of strong unions and rigid labor laws, it managed to avoid high structural unemployment through a combination of hidden unemployment in public sector jobs, an extremely low participation rate, import restrictions, and an underdeveloped financial market. The cost came in the form of very low productivity and frequent inflationary and balance-of-payments crises. High unemployment has recently materialized following a series of recent reforms, affecting trade and the public sector, and macroeconomic shocks. Output has grown by about 40 percent over the last six years — despite a deep recession during 1995 — and capital has not fallen short. Unemployment, on the other hand, has increased more or less steadily during that period, and surged during the 1995 recession. It is now stuck at official rates around 18 percent.[43]

It is not unreasonable to surmise that this combination of growth and high unemployment is rooted in the interaction of appropriability and factor substitution we have analyzed in this paper. Opening to trade certainly facilitates specialization, and therefore potential factor substitution. At the same time, importing machinery and new methods of production has become easier than ever before. Compared to the relatively arduous path of technological substitution in frontier European countries, which often had to develop their own capital-intensive technologies, one must wonder with apprehension how serious the problem may become for a country like Argentina, which faces a much larger set of readily available technologies and opportunities for capital deepening. On the other hand, although it may have the labor-market institutions of Europe since the 1970s, Argentina, with so much catching up to do, may benefit from the growth rates

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[43] Considering the high degree of underemployment and the depressed participation rate, the true scale of the problem is much larger.

of the Europe of the 1950s and 60s.

Another type of environmental change that may put institutions under pressure is a deterioration in aggregate conditions, which may unbalance a previously well-functioning institutional framework — a point we develop in Caballero and Hammour (1996c). We have argued that such a shock does not account well for the European experience; but it may well be relevant elsewhere, if we think of the recent labor-market tensions and aborted attempt at reforms in a troubled economy like Korea.

6. Appendix

6.1. A Chronology of Post-War French Labor-Market Developments

1945: The *comité d'entreprise* is instituted in firms with more than 100 employees, a consultative body that groups management and employee representatives (February 22). The generalized social security system is instituted, which applies to all wage-earners and covers health, retirement, maternity, workplace accidents, and invalidity (October 4).

1946: The 40-hour work-week is re-established, with the possibility of overtime work (February 25). Because of labor shortages, the average work-week remains near 45 hours until the mid-60s. Creation of the CNPF (*Conseil national du patronat français*) to represent corporate interests.

1948: The CGT-FO labor union is created (*Force ouvrière*), whose members separated from the CGT, which they perceived as excessively close to the Communist Party (April). Wave of strikes (October 1).

1950: Minimum wage legislation is introduced in the form of the SMIG (*salaire minimum interprofessionnel garanti*) (February). The right to strike is extended to public servants.

1952: A "mobile wage scale" is adopted, with automatic indexation for the SMIG as a way to introduce price discipline (July 18).

1953: A 1% payroll tax is introduced for private firms with more than 10 employees, to finance housing construction.

1958: The UNEDIC is created, a privately-financed unemployment insurance system (December 31). Unemployment insurance had previously been limited to unsystematic, small public assistance.

1964: The CFDT labor union is created as a non-religious offshoot of the CFTC (November).

1967: The national employment agency, ANPE, is created (July 13). The unemployment insurance system is reformed, with municipal funds being replaced by state benefits.

1968: Student revolts are followed by a general strike of 9 million employees, that paralyzes the economy (May 22). The Grenelle accords (May 27) bring about large wage increases (the SMIG is increased by 35%), and ultimately lead to accords on the reduction of the work-week and to the creation of union representation at the firm level. The National Assembly is dissolved (May 30). Work resumes in many sectors; attempts at restarting strikes lead to violence at the Renault factory in Flins (June 3-6).

1969: A fourth week of paid vacation introduced.

1970: The SMIG turns into the SMIC (*salaire minimum interprofessionnel de croissance*), which is indexed to the price level and, partly, to average real wages. Renault, promptly followed in many sectors of the economy, changes manufacturing employment contracts from an hourly to a monthly wage system.

1973: The law of July 13 regulates employee dismissals, and requires "real and serious" motives. The first oil shock causes the value of oil imports to rise from 1.5% to 4.5% of GDP (October).

1974: Valéry Giscard d'Estaing is elected president (May 19). The country's borders are officially closed to foreign immigration (July).

1975: The law of January 3 imposes an administrative authorization for economically-motivated dismissals.

1977: The distinction between hourly and monthly employment is fully eliminated.

1981: François Mitterrand is elected president (May 10). The stock market falls by 20% within a few days. Exchange controls are introduced. Mitterrand dissolves the National Assembly, and brings about a socialist-communist coalition government. Between June 1981 and March 1983, the SMIC is increased several times, by a total of about 40%. In two years, 110,000 public-sector jobs are created. The work-week is reduced to 39 hours, and a fifth week of paid vacation is adopted (July).

1982: Restrictions are imposed on temporary work and determined-duration contracts (February). A program adopted to nationalize major industrial groups and banks (February). The Auroux labor laws are adopted. The first Auroux law institutes the employee's right of expression within the firm concerning work conditions and organization (August 4). The second law introduces new representative institutions for employees and reinforces the role of the *comité d'entreprise* (October 28). The third law broadens the scope of collective agreements, and makes annual wage negotiations mandatory (November 13). The fourth law institutes hygiene and security committees in all firms with more than 50 employees (December 23).

1983: The retirement age is reduced from 65 to 60 years, and the possibility for early-retirement at age 55 is extended (April).

1984: An industrial restructuring plan is adopted, that involves job losses in the steel, coal, and naval construction industries (March).

1986: Legislative elections bring right-wing parties to power (March). The removal of exchange controls begins. The administrative authorization for dismissals is eliminated (July 3). A privatization program is started with the sale of Saint-Gobain (December).

1987: Growth resumes, with GDP growing briskly for the next three years. Corporate taxes are reduced from 50% to 42%.

1988: François Mitterrand is re-elected president, and the socialists return to power (May). The RMI (*revenu minimum d'insertion*) is instituted.

1990: Exchange controls are eliminated (January 1).

1991: Introduction of the CSG (*contribution sociale généralisée*), which partly shifts the financing of the social security system to non-wage income.

1993: The corporate tax rate is reduced to 33.33%. Parliamentary elections bring right-wing parties back to power (May). Currency crises, including the French Franc, are followed by a widening of the EMS currency bands from ±2.25 percent to ±15 percent (August).

1994: Two decrees institute the CIP (*contrat d'insertion professionnelle*), which involves paying young workers 80 percent of the SMIC (February). After a wave of protests by students and by labor unions, the CIP is replaced by subsidies for the hiring of young workers (March).

1995: Jacques Chirac is elected president (May). Economics minister Alain Madelin resigns, in disagreement with the limited scope of the government's economic reform program (September).

Sources: Teulon (1996); Rivero and Savatier (1993).

6.2. Equilibrium Conditions in Section 3

This appendix derives the equilibrium conditions for the model in section 3, as well as the path of wage payments.

Definitions

For the purposes of this appendix we redefine a production unit as combining a fixed amount n_0 of labor with an endogenous amount $k(t_0)$ of capital, where t_0 is the unit's time of creation. The unit's capital intensity is $\kappa(t_0) \equiv k(t_0) \div A(t_0)n_0$. In the main text, we normalize $n_0 \equiv 1$. Consider a production unit created at time t_0. At any time $t \in [t_0, T(t_0)]$, we define the following variables:

$W^e(t; t_0)$ is the human wealth of a worker employed in the production unit;
$W^u(t)$ is the human wealth of an unemployed worker;
$\Pi(t; t_0)$ is the present value to the firm of profits from the production unit;
$V(t; t_0)$ is the value to the firm of the unit's non-specific capital;
$S(t; t_0)$ is the value of specific quasi-rents in the unit. In the main text, we define $S(t) \equiv S(t; t)$.

By definition, the above present values must satisfy three arbitrage equations. The human wealth of an employed worker must satisfy

$$\begin{cases} rW^e(t; t_0) = w(t; t_0)A(t) - \delta\left[W^e(t; t_0) - W^u(t; t_0)\right] + \frac{d}{dt}W^e(t; t_0); \\ \text{with} \quad W^e(t_0 + T(t_0); t_0) = W^u(t_0 + T(t_0)). \end{cases} \tag{6.1}$$

The human wealth of an unemployed worker must satisfy

$$rW^u(t) = \widetilde{w}(t)A(t) + \frac{d}{dt}W^u(t), \tag{6.2}$$

where $\widetilde{w}(t)$ was defined in (3.9). The value of profits must satisfy

$$\begin{cases} r\Pi(t; t_0) = F\left(k(t_0), A(t)n_0\right) - \left[w(t; t_0) + \tau(t)\right]A(t)n_0 - \delta\Pi(t; t_0) + \frac{d}{dt}\Pi(t; t_0); \\ \text{with} \quad \Pi(t_0 + T(t_0); t_0) = V(t_0 + T(t_0); t_0) - x^f(t_0 + T(t_0))A(t_0 + T(t_0))n_0. \end{cases} \tag{6.3}$$

Bargaining and free entry

Specific quasi-rents in a production unit are equal to

$$S(t; t_0) = [\Pi(t; t_0) + W^e(t; t_0)n_0] - \left[V(t; t_0) - x^f(t)A(t)n_0\right] - W^u(t)n_0. \tag{6.4}$$

Assuming continuous-time Nash bargaining, the path of wages $w(t; t_0)$ is such that each factor obtains, at any point in time, its outside opportunity cost plus its share of quasi-rents:

$$W^e(t; t_0)n_0 = W^u(t)n_0 + \beta S(t; t_0); \tag{6.5}$$

$$\Pi(t; t_0) = \left[V(t; t_0) - x^f(t)A(t)n_0\right] + (1 - \beta)S(t; t_0). \tag{6.6}$$

26

By free entry, the value of profits at the time of creation is given by

$$\Pi(t_0; t_0) = c(i(t_0))A(t_0)k_0(t_0). \tag{6.7}$$

Moreover, assuming free disposal, the value of a unit's non-specific capital must satisfy

$$V(t; t_0) = \max\left\{0, \Pi(t; t_0) - c(i(t))A(t)\overline{\phi}(t)n_0\right\}. \tag{6.8}$$

Equation (6.8) states that if the firm separates from its existing workers, it must re-invest $\overline{\phi}(t)$ units of specific capital to replace each worker and recover the value $\Pi(t; t_0)$.[44]

Equilibrium conditions

We now turn to the derivation of the model's equilibrium conditions. Let us start with expression (3.8) for the value of *specific quasi-rents*, $S(t) \equiv S(t; t)$. First, use (6.4) to express $\Pi + W^e$ as a function of S, replace into (6.1)+(6.3) and subtract (6.2)×n_0:

$$(r + \delta)\left[S(t; t_0) + V(t; t_0) - x^f(t)A(t)n_0\right]$$

$$= F(k(t_0), A(t)n_0) - [\widetilde{w}(t) + \tau(t)]A(t)n_0 + \frac{d}{dt}\left[S(t; t_0) + V(t; t_0) - x^f(t)A(t)n_0\right].$$

Integrate this expression, using the boundary condition

$$S(t_0 + T(t_0); t_0) = 0,$$

which can be derived from (6.4) and the boundary conditions in (6.1) and (6.3), to get

$$S(t; t_0) = \int_t^{t_0+T(t_0)} [F(k(t_0), n_0)A(t) - (\widetilde{w}(s) + \tau(s))A(s)n_0] e^{-(r+\delta)(s-t)} ds$$

$$- x^f(t_0 + T(t_0))A(t_0 + T(t_0))n_0 e^{-(r+\delta)(t_0+T(t_0)-t)} - \left[V(t; t_0) - x^f(t)A(t)n_0\right] \tag{6.9}$$

This expression implies (3.8) given in the main text, once we set $n_0 = 1$ and use (6.7) and (6.8) to write

$$V(t_0; t_0) = c(i(t_0))A(t_0)\left[k_0(t_0) - \overline{\phi}(t_0)n_0\right] \tag{6.10}$$

(which is non-negative, because specific capital cannot exceed total capital).

Free-entry condition (3.10) in the main text is obtained by replacing (6.6) into (6.7), taking (6.10) into account, and setting $n_0 = 1$.

Exit condition (3.11) and *first-order condition* (3.12) are obtained from profit maximization. Replacing (6.9) into (6.6) when $t = t_0$ and taking (6.10) into account, we get the expression

$$\Pi(t_0; t_0) = (1 - \beta)\int_{t_0}^{t_0+T(t_0)} [F(k(t_0), n_0)A(t_0) - (\widetilde{w}(s) + \tau(s))A(s)n_0] e^{-(r+\delta)(s-t_0)} ds$$

$$- (1 - \beta)x^f(t_0 + T(t_0))A(t_0 + T(t_0))n_0 e^{-(r+\delta)T(t_0)}$$

$$+ \beta c(i(t_0))A(t_0)\left[k_0(t_0) - \overline{\phi}(t_0)n_0\right] - \beta x^f(t_0)A(t_0)n_0.$$

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[44] We assume that any anticipated decreases in $c(i(t))A(t)\overline{\phi}(t)n_0$ are not sharp enough to make efficient a strategy of hoarding non-specific capital after separation, until such a time when specific investment is expected to be much lower.

Profit maximization can be thought of as the problem of a firm who enters at t_0 with $k(t_0)$ units of capital, and maximizes the above expression for $\Pi(t_0; t_0)$ with respect to $T(t_0)$ and n_0, taking constraint (3.2) into account. The first-order condition with respect to $T(t_0)$ yields exit condition (3.11), once we take (3.7) into account and set $n_0 = 1$. If (3.2) is not binding, the first-order condition with respect to n_0 is

$$\int_{t_0}^{t_0+T(t_0)} \frac{\partial F}{\partial n}(k(t_0), n_0) A(t_0) e^{-(r+\delta)(s-t_0)} ds$$

$$= \int_{t_0}^{t_0+T(t_0)} [\tilde{w}(s) + \tau(s)] A(s) e^{-(r+\delta)(s-t_0)} ds + x^f(t_0 + T(t_0)) A(t_0 + T(t_0)) e^{-(r+\delta)T(t_0)}$$

$$+ \frac{\beta}{1-\beta} \left[c(i(t_0)) A(t_0) \overline{\phi}(t_0) + x^f(t_0) A(t_0) \right]; \tag{6.11}$$

if (3.2) is binding, the above condition is replaced by the appropriate inequality.

A few steps are needed to derive first-order condition (3.12) in the main text from (6.11). Replacing (3.10) into (6.5) when $t = t_0$, the term on the third line of (6.11) can be shown to be equal to a worker's share of quasi-rents:

$$\frac{\beta}{1-\beta} \left[c(i(t_0)) A(t_0) \overline{\phi}(t_0) + x^f(t_0) A(t_0) \right] = W^e(t_0; t_0) - W^u(t_0; t_0).$$

Worker rents can, in turn, can be written as

$$W^e(t; t_0) - W^u(t; t_0) = \int_t^{t_0+T(t_0)} [w(s, t_0) - \tilde{w}(s)] A(s) e^{-(r+\delta)(s-t)} ds. \tag{6.12}$$

This expression is obtained if we subtract (6.2) from (6.1) and integrate using the terminal condition in (6.1). Replacing into (6.11) and setting $n_0 = 1$ immediately yields (3.12).

Wages

We are left with the characterization of the path $\{w(t; t_0)\}_{t \in [t_0, t_0+T(t_0)]}$ of wages for a unit created at t_0. By (6.5) and (6.12), the present value of remaining wage payments at any time $t \in [t_0, t_0 + T(t_0)]$ can be expressed as

$$\int_t^{t_0+T(t_0)} w(s, t_0) A(s) e^{-(r+\delta)(s-t)} ds = \int_t^{t_0+T(t_0)} \tilde{w}(s) A(s) e^{-(r+\delta)(s-t)} ds + \beta S(t; t_0).$$

The path of wages is obtained by differentiating the above expression with respect to t. To do so, we need an expression for the rent component $\beta S(t; t_0)$.

Let $t^*(t_0) \in [t_0, t_0 + T(t_0)]$ denote the first time at which the value $V(t^*(t_0); t_0)$ on the unit's non-specific capital reaches zero. In the event of premature separation at time t, the firm will find it profitable to replace the worker if and only if $t < t^*(t_0)$. In that case, replacing (6.8) into (6.4) and taking (6.5) into account, we can write

$$S(t; t_0) = \frac{1}{1-\beta} \left[c(i(t)) A(t) \overline{\phi}(t) n_0 + x^f(t) A(t) n_0 \right], \quad t < t^*(t_0). \tag{6.13}$$

On the other hand, if $t \geq t^*(t_0)$, we can set $V(t; t_0) = 0$ into (6.9) and write

$$S(t; t_0) = \int_t^{t_0+T(t_0)} [F(k(t_0), n_0) A(t_0) - (\tilde{w}(s) + \tau(s)) A(s) n_0] e^{-(r+\delta)(s-t)} ds$$
$$+ x^f(t) A(t) n_0 - x^f(t_0 + T(t_0)) A(t_0 + T(t_0)) n_0 e^{-(r+\delta)T(t_0)}, \quad t \geq t^*(t_0). \tag{6.14}$$

28

Equations (6.13)-(6.14) determine $S(t; t_0)$ for t before and after $t^*(t_0)$, which in turn is implicitly determined by equating those two expressions.

References

[1] Blanchard, O.J. (1997): "The Evolution of Profit Rates in the OECD," MIT notes.

[2] Bentolila, S. and G. Bertola (1990): "Firing Costs and Labor Demand," *Review of Economic Studies,* 57, 381–402.

[3] Berger, S. and M.J. Piore (1980): *Dualism and Discontinuity in Industrial Societies,* New York: Cambridge University Press.

[4] Bertola, G. (1990): "Job Security, Employment and Wages," *European Economic Review,* 34, 851–886.

[5] Bruno, Michael, and Jeffrey Sachs (1985): *Economics of Worldwide Stagflation,* Cambridge, Ma.: Harvard University Press.

[6] Caballero, R.J., and M.L. Hammour (1994): "The Cleansing Effect of Recessions," *American Economic Review,* 84, 1350-1368.

[7] —— (1996a): "On the Timing and Efficiency of Creative Destruction," *Quarterly Journal of Economics,* 111, 805-852.

[8] —— (1996b): "On the Ills of Adjustment," *Journal of Development Economics,* 51, 161-192.

[9] —— (1996c): "The Macroeconomics of Specificity," NBER Working Paper No. 5757, September.

[10] —— (1997): "Improper Churn: Social Costs and Macroeconomic Consequences," typescript, MIT.

[11] Coe, D.T. and D.J. Snower (1996): "Policy Complementarities: The Case for Fundamental Labor Market Reform," IMF Working Paper, July.

[12] Emerson, M. (1988): "Regulation and Deregulation of the Labour Market: Policy Regimes for the Recruitment and Dismissal of Employees in the Industrialised Countries," *European Economic Review,* 32, 775-817.

[13] Keese, M., G. Salou, and P. Richardson (1991): "The Measurement of Output and Factors of Production for the Business Sector in OECD Countries (The OECD Business Sector Data Base)," OECD Economics and Statistics Working Paper No. 99, May.

[14] Kouri, P., J. de Macedo and A. Viscio (1985): "Profitability, Employment and Structural Adjustment in France," in J. Melitz and C. Wyplosz (eds.), *The French Economy,* London: Westview Press.

[15] Krugman, P. (1985): "The Real Wage Gap and Employment," in J. Melitz and C. Wyplosz (eds.), *The French Economy,* London: Westview Press.

[16] Lazear, E.P. (1990): "Job Security Provisions and Employment," *Quarterly Journal of Economics*, 105, 699–726.

[17] Melitz, J., and C. Wyplosz (1985): *The French Economy*, London: Westview Press.

[18] Mortensen, D.T. (1978): "Specific Capital and Labor Turnover," *The Bell Journal of Economics,* 9 572–586.

[19] OECD (1993): *Employment Outlook*. Paris: OECD.

[20] OECD (1986): *Flexibility in the Labour Market: The current debate*, Technical report.

[21] Rivero, J., and J. Savatier (1993): *Droit du Travail*. Paris: Presses Universitaires de France.

[22] Sachs, J. (1979): "Wages, Profits, and Macroeconomic Adjustment: A Comparative Study," *Brookings Papers on Economic Activity 2*, 269–319.

[23] Saint-Paul, G. (1993): "On the Political Economy of Labor Market Flexibility," *NBER Macroeconomics Annual,* 8, 151-187.

[24] Teulon, F. (1996): *Chronologie de l'Economie Française,* Paris: le Seuil.

[25] Wolff, E.N. (1996): "The Productivity Slowdown: The Culprit at Last? Follow-Up on Hulten and Wolff," *American Economic Review,* 86, 1239–1252.

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